Marlborough Creek Erosion Mitigation Assessment

6038 Ottawa Street

Ottawa (Richmond), Ontario

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1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained by David Schaeffer Engineering Ltd. (DSEL) to complete a fluvial geomorphological assessment of existing conditions along Marlborough Creek to support the proposed development at 6038 Ottawa Street in the City of Ottawa (Richmond), Ontario. The proposed development includes residential, commercial and natural land uses and is approximately 67 hectares in area. Additionally, a stormwater management pond for the development, located east of Ottawa Street, is proposed to outlet to Marlborough Creek.

A preliminary Fluvial Geomorphology Report was submitted on February 26, 2021, and included a review of background reports and mapping, watercourse reach delineation, a review of recent and historical aerial photographs, and delineation of a preliminary meander belt width. The preliminary report (GEO Morphix Ltd., 2021) was based on a desktop assessment only. In April 2021, field reconnaissance was completed to confirm existing site conditions and finalize the geomorphic assessment. The field investigation verified our findings from the desktop assessment and confirmed there were no changes to the initial findings. A complete summary of the geomorphic assessment was provided in the updated Meander Belt Width Report (GEO Morphix Ltd. 2025).

In support of the proposed SWM pond, an erosion threshold and erosion exceedance assessment based on the results of the geomorphological assessment are provided in this report. The overall objective of the current study is to evaluate the SWM plan for the proposed development to determine its effectiveness in mitigating changes to erosion potential along the receiving watercourse. The following tasks were completed as part of the assessment:

- Review of existing documentation related to the subject lands, including topography, physiography, and geology mapping, as well as previously completed studies
- Delineate watercourse reaches based on a desktop assessment and confirm reach delineation through geomorphic field observations
- Conduct field reconnaissance using standard, industry-accepted tools such as the rapid geomorphic assessment (RGA) and rapid stream assessment technique (RSAT) to evaluate existing instream and riparian conditions along the downstream receiving reaches (i.e., evidence of ongoing channel processes, active erosion/deposition, or potential channel instability)
- Complete one detailed geomorphological assessment in the potential zone of impact along the receiving watercourse
- Complete the erosion threshold assessment based on detailed assessment results to determine the limiting erosion threshold value and inform the erosion exceedance analysis
- Complete the erosion exceedance analysis using the determined erosion threshold value to inform stormwater mitigation strategies and SWM pond sizing and release rates to address erosion mitigation requirements

2 Desktop Assessment

2.1 Background Information

The subject property is within the Rideau Valley watershed, and more specifically, the Jock River subwatershed (Richmond catchment). The Jock River-Richmond subwatershed drains an area of approximately 31 square kilometres with approximately 60 km of channel length (including both Jock River and tributaries; RVCA, 2016). The dominant land cover within the Jock River-Richmond catchment is crop and pasture (47%) followed by woodlands and wetlands at 16% and 15%, respectively (RVCA, 2016).

Immediately adjacent to the subject property, Marlborough Creek flows in a northern direction, originating north of Dobbs Road and flows towards its confluence with the Jock River, located just south of the intersection of Old Richmond Road and Eagleson Road. The length of Marlborough Creek that was assessed is approximately 2.5 km, originating from McBean Street, and flowing alongside private property and agricultural fields before crossing under Ottawa Street. Between Ottawa Street and the railroad tracks, the watercourse becomes a pond and narrows again as it crosses under the rail line. The channel then flows parallel to the rail line upstream of Eagleson Road where the floodplain widens and

is heavily vegetated. The dominant land use surrounding the subject reaches is agriculture and residential.

For reference, a study area mapping is provided in **Appendix A.**

2.2 Physiography and Surficial Geology

Geology and physiography act as primary controls on channel morphology as they influence the hydrological and sediment characteristics of the channel system. Channel morphodynamics are governed by the channel's flow regime and the availability and type of sediments within the stream corridor. These factors are explored as they offer insight into existing conditions and potential changes to the channel that may result from the proposed development. Understanding local surficial geology is important for determining appropriate erosion thresholds, as the stability of the channel banks and bed depends on the composition of soils, sediment, and underlying parent materials (MNR, 2002).

The subject property is located in the Clay Plains physiographic region of Ontario (Chapman and Putnam, 2007). The surficial geology associated with Marlborough Creek largely contributes to its planform and channel stability. The surficial sediments at the subject lands are characterized as fine-textured (clay, silt) glaciomarine deposits, deposited in the offshore environment of the Champlain Sea during the Wisconsinan Glaciation (OGS, 2010). Surficial deposits and substrate within the subject property include silt and clay, minor sand, and gravel (OGS, 2010). Upstream of the subject lands, Marlborough Creek flows through lands characterized by Paleozoic bedrock and thin deposits of glacial till (OGS, 2010).

Fine-textured sediments deposited within offshore glacio-marine or marine environments, like those observed at surface within the subject lands, may be subject to sensitivity and erosion due to high pore pressure and low shear strength when disturbed (Mayne, Cargill & Miller, 2019; Brooks, 2019). Disruptions, such as erosional slope failure, construction activities, or seismic activity, may trigger further rotational slope failures. While slope failures are well documented within Eastern Ontario and The City of Ottawa (Brooks, 2019), no such failures have been documented along Marlborough Creek, nor were any visible slump scars identified during the desktop review of LiDAR data for the area. Additionally, Marlborough Creek occurs within a generally unconfined system and has limited sinuosity, further limiting the likelihood of disruptions along the outside of meander bends.

For reference, a map of local surficial geology is provided in **Appendix A.**

3 Watercourse Characteristics

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a particular reach, for example, as it relates to a proposed activity. Reaches are typically delineated based on changes in the following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Historical channel modifications

Reach delineation follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), the Toronto and Region Conservation Authority (2004) and others. watercourse reaches were delineated adjacent to and downstream of the subject site based on a desktop assessment of available

data (e.g., MNRF stream layer, surficial geology, historical and recent aerial photographs, topographic data.

Reach **MC1** was previously named and delineated for the 2021 Preliminary Fluvial Geomorphology Report (GEO Morphix Ltd., 2021). An additional 5 reaches were delineated downstream (**MC2, MC3, MC4, MC5** and **MC6).** Reach mapping is provided in **Appendix A** for reference.

3.2 Reach Observations

Field investigations were completed on July 8th, 2025 and included the following tasks:

- Describe riparian conditions
- Estimate bankfull channel dimensions
- Characterize bed and bank material composition and structure
- Collect observations of erosion, scour, or deposition
- Compile photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures

The observations and measurements collected during field activities are summarized in **Table 1**. Field descriptions are supplemented and supported with representative photographs, which are included in **Appendix B**. Field observations are provided in **Appendix C**.

Table 1: Summary of general reach characteristics.

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Confinement	Notes
MC1[1]	7.4	Too deep	Gravel, Cobble	Clay/Silt, Sand, Gravel	Trees, grasses	Partially Confined	• Reach heavily encroached with cattails • Large boulders noted within the floodplain • No evidence of erosion noted
MC2[2]	N/A	N/A	Clay/Silt		Trees, shrubs	Unconfined	• No riffle pool formation, all runs • Dense instream vegetation • Wetted depth >1.0 meters, sediment depth of >0.75m at start of reach and 0.3m near end of reach • No undercutting, low bank angle
MC3[3]	4.1	0.22	Clay/Silt, Sand, Gravel		Trees, shrubs, grasses, herbaceous plants	Partially Confined	• Two instances of exposed mature tree roots • Low and generally stable banks • CN railway acts as right bank of channel • Substrate ranged from silt to large cobble with 2 riffles along straightened reach • Sediment depth at start of reach of 0.15m and 0.64m at end of reach likely due to wetland/swamp like conditions at end of reach

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Confinement	Notes
MC4[2]	N/A	N/A	Clay/Silt		Trees, shrubs	Partially Confined	• Channel is heavily vegetated with cattails and European frogbit • No velocity, sediment depth regularly exceeds double wetted depth • Wetted depth 0.29m at start of reach and 0.38m at end of reach • Sediment depth 0.55m at start of reach, >1.0m at end of reach
MC5[2]	N/A	N/A	Clay/Silt		Trees, shrubs	Unconfined	• Right bank forested and left bank with a minimal buffer due to agricultural field • Wetted depth ~0.4m, sediment depth >0.6m • No flow, no defined channel • Dense instream vegetation covers 100% of the reach, cattails about 2m tall
MC6[2]	N/A	N/A	Clay, Silt, Sand		Trees, shrubs, grasses	Unconfined	• Straight channel, no flow • Small culvert under farm road crossing at end of reach before confluence with Jock River • Riparian vegetation very limited due to agricultural fields on both banks • Dense instream duckweed vegetation

[1]*Observations from the 2021 Meander Belt Width Report (GEO Morphix Ltd., 2021)*

[2]*Bankfull measurements were not collected due to poor bankfull indicators and lack of channel definition*

[3]*Bankfull dimensions from detailed assessment survey*

Reach MC1 was mostly unconfined, but several constructed berms flanking its floodplain (e.g., between the two culverted crossings on private property, upstream of the Ottawa Street crossing), create a localized area of partial confinement. Generally, there was approximately 2 meters rise between bed of the channel and the adjacent tableland, connected by moderately sloped banks and a well-connected floodplain. The channel was slightly sinuous (1.06-1.30) within a linear floodplain. Portions of **Reach MC1** were well-defined, while the majority of the channel exhibited poor bed and bank definition. Where defined, the average channel width is approximately 2.5 metres and encroached upon by riparian vegetation, with occasional riffle features and vegetated bars and islands. Pool features, averaging approximately 11.5 metres width, were observed downstream of the McBean Street crossing and both upstream and downstream of the two private channel crossings located mid-reach. The bed substrate was moderately well sorted, with riffles consisting of gravel and cobble-sized clasts, and pool substrate composed of clay, silt, sand, and gravel-sized clasts; larger cobble and boulder clasts occurred along the floodplain but appeared to have been mechanically placed (i.e., removing stones to prepare land for cultivation). Banks were entirely covered by established and stable riparian vegetation. Wetland submergent and emergent vegetation occurred continuously along the floodplain of the reach, occasionally spanning the channel and causing it to become undefined. Beyond the wetland-occupied floodplain, riparian vegetation becomes less continuous as the riparian vegetation transitions to established trees (5-30 years) and grass species.

Reach **MC2** was situated within an unconfined valley setting and was characteristic of a wide, stagnant pond. The riparian vegetation was composed of established trees, and woody debris was noted along the banks. Instream vegetation was dense, and the surface of the water was completely covered by rooted emergent and floating vegetation. The banks were composed of silt and were low and well-vegetated. No signs of erosion were noted. The bed was composed of deep silt (up to 0.75m) and organic material. The channel was approximately 17m wide along the reach but narrows as it flows under the railway tracks and transitions into reach **MC3.**

Reach **MC3** flows within a partially confined valley system due to the railway tracks that run along the right bank. Along the left bank, the channel was unconfined, with a measured bankfull height of approximately 0.22m. The bank's slopes were shallow (0-30°) and stable. The channel appears to have been straightened, most likely to accommodate the construction of the railway prior to 1954 (GEO Morphix, 2021). Generally, the bed morphology was composed of runs, with few pools and riffles noted, and minimal flow. The bed substrate was composed of clay/silt, sand and gravel with observations of cobbles in the riffles. Instream vegetation was prominent, including duckweed, cattails and algae. The banks were well vegetated, composed of mature trees and grasses along the left bank and grasses along the right bank adjacent to the railway. No signs of erosion were noted, and siltation was noted in a few isolated areas.

Reach **MC4** flows within a partially confined valley setting due to agricultural fields located along the edges of the floodplain. The channel exhibited low sinuosity as it flowed through a broad, grassy floodplain. The bankfull width and depth were difficult to discern throughout the reach as there was poor channel definition, and vegetation encroachment was heavy; however, estimated bankfull width and depths were 17 m and 0.88 m, respectively. No pools or riffles were identified throughout the reach and at the time of assessment, there was no flow. The bed substrate was composed of silt, up to 1m deep along the downstream extent. Instream vegetation was dense and composed of algae, floating, and rooted emergent vegetation that covered up to 90% of the surface. The banks, where discernible, were well vegetated and stable. No signs of erosion were noted, and deep pockets of silt were noted; however, it is characteristic of wide vegetated floodplains as observed.

Reach **MC5** is situated within an unconfined valley setting, and flows through a poorly defined channel which is heavily encroached upon by vegetation within a wide floodplain. Bankfull width and depths were difficult to identify due to the lack of definition; however, the floodplain was estimated to be 40m across and channel depth to be 0.3-0.4m. There were no pools or riffles identified, and at the time of the assessment, the flows were stagnant. The bed substrate was composed of deep silt, up to 0.60m deep. Instream vegetation was dense and composed of rooted emergent vegetation, which covered approximately 90% of the reach. An established forest was observed along the right edge of the floodplain, and along the left was a narrow grassy buffer between the channel and an agricultural field. No signs of erosion were noted throughout the reach, and siltation was observed; however, it is characteristic of a wide vegetated floodplain.

Reach **MC6** exhibited similar characteristics to **MC5**. The reach is situated within an unconfined valley system and extends through the wide floodplain to its confluence with the Jock River. Defined bankfull widths and depths were difficult to observe; however the floodplain was estimated to be 27m wide and 1.6m deep. One instance of a riffle-pool sequence was observed towards the downstream extent of the reach; otherwise, the channel exhibited wetland characteristics with stagnant water and abundant aquatic vegetation. The bed substrate was composed of silt, up to 0.30m deep, and instream vegetation, including cattails and floating instream vegetation was dense. Riparian vegetation along the edges of the floodplain was limited due to adjacent agricultural fields. A small culvert conveys flow under a narrow farm access crossing, immediately upstream of the confluence with the Jock River. No erosion was observed along the length of the reach.

3.3 Rapid Assessment Results

Channel instability was objectively quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel

widening, and planimetric adjustment. The index produces values that indicate whether a channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system as it considers the ecological function of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (35-42) degree of stream health.

Reaches were also classified according to the Downs (1995) Channel Evolution Model. The Downs Model describes the successional stages of a channel because of perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system.

These observations and measurements are summarized below and in **Table 2**.

Table 2: Summary of rapid assessment results.

Reach Name	RGA (MOE, 2001)			RSAT (Galli, 1996)			Down's (1995) Classification
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
MC1*	0.140	In Regime	Widening	30	Good	Riparian Habitat Conditions	s/d
MC2	0.107	In Regime	Aggradation	20	Fair	Physical Instream Habitat, Riparian Habitat Conditions	D
MC3	0.137	In Regime	Aggradation	22	Fair	Riparian Habitat Conditions	D
MC4	0.137	In Regime	Aggradation	23	Fair	Riparian Habitat Conditions	D
MC5	0.140	In Regime	Aggradation	20	Fair	Riparian Habitat Conditions	D
MC6	0.140	In Regime	Widening	24	Fair	Riparian Habitat Conditions	D

**Observations collected in 2021 for the updated Meander Belt Width Report (GEO Morphix Ltd., 2025)*

Reach MC1 was assigned an RGA score of 0.140, indicating the reach was in regime. The dominant geomorphological indicator was evidence of widening due to the observations of fallen and leaning trees and the occurrence of large organic debris. However, it is important to note that falling and leaning trees were likely attributed to human modification adjacent to the watercourse rather than from active channel processes. **Reach MC1** had an RSAT score of 30, or "good". One limiting factor, riparian habitat conditions, was attributed to the narrow riparian area outside of the well-connected flood plain, which was predominantly wooded vegetation (i.e., trees) and fragmented in some areas.

Reach MC2 was assigned an RGA score of 0.107, indicating that the reach is in regime. The dominant geomorphological indicator was aggradation due to observations of siltation in pools and poorly sorted

bed materials. It important to note that only minor instances of these indicators were observed. The reach received an RSAT score of 20, or fair. The limiting feature was physical instream habitat and riparian habitat conditions due to a lack of canopy coverage and non-woody riparian edges.

Reach MC3 was assigned an RGA score of 0.137, indicating that the reach is in regime. Aggradation was the dominant systematic adjustment due to observations of siltation in pools and poorly sorted bed materials. Similar to **MC2**, only minor instances of these indicators were observed. An RSAT score of 22, or fair was assigned. The limiting feature was riparian habitat conditions due to the lack of woody vegetation.

Reach MC4 was assigned an RGA score of 0.137, indicating that the reach is in regime. The dominant systematic adjustment was aggradation. Minor instances of siltation in pools and poorly sorted bed materials were observed. An RSAT score of 23, or fair was assigned to the reach. The limiting feature was riparian habitat conditions due to a lack of woody vegetation within the riparian edges.

Reach MC5 received and RGA score of 0.140, indicating that the reach is in regime. The dominant systematic adjustment was aggradation due to observations of siltation in the pools. The reach received an RSAT score of 20 or fair. The limiting feature was riparian habitat conditions due to the lack of woody riparian vegetation and canopy coverage.

Reach MC6 was assigned an RGA score of 0.140 indicating that the reach is in regime. The dominant systematic adjustment was widening due to fallen and leaning trees. Note there were very few instances of this indicator noted. An RSAT score of 24, or fair was assigned and the limiting feature was riparian habitat conditions due to the lack of woody riparian vegetation and poor canopy coverage.

3.4 Detailed Geomorphological Assessments

A detailed assessment was completed for the most erosion-sensitive reach along Marlborough Creek. Based on results from the rapid geomorphic assessments, Reach **MC3** was selected for detailed assessments, it is located downstream from the proposed SWM Pond, exhibits minor evidence of bed erosion, and was well-defined in comparison with the other assessed reaches. **Reaches MC2** and **MC4-MC6** were all determined to be in regime, with no evidence of active erosion or channel adjustment and with portions of the reaches noted to be poorly-defined. While evidence of erosion was observed along Reach MC1, the majority of the reach was poorly-defined. Additionally, the SWM Pond is proposed to discharge at the downstream extent of **Reach MC1**. Thus, the detailed assessment was completed for **Reach MC3** on July 9th, 2025.

Detailed geomorphological assessments provide bankfull channel characteristics for the purpose of defining the erosion threshold, and include the following field activities:

- Long-profile, level survey of the channel centre line
- Detailed cross-sectional surveys at multiple locations along the subject channel reach
- Detailed instream measurements at each cross-section location including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density
- Bed material sampling at each cross-section following a modified Wolman's (1954) Pebble Count Technique and/or substrate samples
- Velocity and discharge measurements at select representative cross-sections

Based on results from the detailed assessment, **Reach MC3** was characterized as a straightened channel flowing through a partially confined valley, with a riparian zone consisting of a continuous coverage of established trees, shrubs and grasses. The channel was dominated by runs, and the banks were generally low and there were minor instances of scour. Siltation was noted in a few pools. Bed substrate ranged from clay/silt to cobbles.

A summary of measured and computed values is presented in **Table 3** and comprehensive detailed assessment summaries are provided in **Appendix D.**

Table 3: Detailed assessment bankfull channel parameters for Reach MC3.

Channel parameters	Reach
	MC3
Measured	
Average bankfull channel width (m)	4.13
Average bankfull channel depth (m)	0.22
Channel bed gradient (%)	0.28
Bankfull gradient (%)	0.49
D_{50} (mm)	0.98
D_{84} (mm)	4.25
Manning's n roughness coefficient	0.040
Computed	
Bankfull Discharge (m^3/s)*	0.66
Average bankfull velocity (m/s)*	0.73

*Based on Manning's Equation

4 Erosion Threshold Assessment

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material. As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. An erosion threshold was modelled from detailed field observations of **Reach MC3** along Marlborough Creek. This reach was selected for the assessment, as it was determined to be relatively erosion-sensitive within the potential zone of impact downstream of the proposed SWM outlet. The erosion threshold is the theoretical point, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on the morphology of the channel and characteristics of the bed and bank materials. Due to variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides the more conservative and limiting estimate of erosion potential. The results of the erosion threshold assessment are provided in **Table 3** below.

4.1 Methods

Erosion threshold targets are determined using different methods depending on the observed sediment characteristics of the channel. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach could also be applied (Villard & Parish, 2003). For cohesive materials, a method such as that described by Komar (1987), or empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1994), could be applied. Villard and Parish (2003) emphasize the importance of selecting methods that reflect local sediment conditions and integrating them into site-specific geomorphic assessments.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge (Villard & Parish, 2003; TRCA 2012). Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity, *U*, or Shear Stress, τ, is calculated at various depths for a representative cross-section until the average velocity or shear stress slightly exceeds the critical threshold of the bed material. The velocity is determined using Manning's approach, where Manning's n value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using the Limerino (1970) approach. A Manning's *n* value of 0.045 was used for the assessment, based on the physical characteristics of the subject reach. The velocity is mathematically represented as:

$$U = \frac{1}{n} d^{2/3} S^{1/2} \quad \text{[Eq. 1]}$$

where, *d* is depth of water, *S* is channel slope, and *n* is the Manning's roughness.

The shear stress is determined using the depth-slope product, which can be applied to the bed of open channels containing fluid undergoing steady flows. The shear stress is mathematically represented as:

$$\tau_0 = d\rho g S \quad \text{[Eq. 2]}$$

Where, τ_0 is shear stress, *d* is the water depth, *ρ* is water density, *g* is acceleration due to gravity, and *S* is the channel slope.

Because only 75% of bed shear stress applies to channel banks in uniform cross sections (Chow, 1959), the erosion threshold is scaled appropriately for these materials.

4.2 Results

Based on results from the detailed assessment for **Reach MC3**, bed substrate consisted primarily of clay and silt with some sand and gravel and isolated embedded cobbles present throughout. From the criteria for fine sandy loam defined by Julien (1998), a critical velocity of 0.45 m/s was determined for bed materials. This resulted in a crucial discharge of 0.190 m^3/s. Bank substrate was composed of loose cohesive silty/sandy clay, based on visual observations and on field measurements using a torvane and a penetrometer. A critical shear stress of 4.79 N/m^2 was determined for bank materials, based on the criteria defined by Chow (1959) for loose sandy clay. This yielded a critical discharge of 0.175 m^3/s for bank materials. As the lesser of the two values a critical discharge of 0.175 m^3/s for bank materials was adopted as the erosion threshold for **Reach MC3**.

Table 4: Channel parameters and erosion threshold results.

Channel Parameters	MC3	
Average bankfull channel width (m)	4.13	
Average bankfull channel depth (m)	0.22	
Bankfull gradient (%)	0.49	
D_{50} (mm)	0.98	
D_{84} (mm)	4.25	
Manning's n roughness coefficient	0.040	
Pre-development drainage area (ha)*	566.5	
Bankfull discharge (m^3/s)**	0.66	
Bankfull velocity (m/s)**	0.73	
Erosion Threshold		
	Bed	**Banks**
Material	Fine sandy loam	Loose sandy clay
Method	(Julien, 1998)	Chow (1959)
Critical velocity (m/s)	0.45	--
Apparent shear stress (N/m^2)	6.74	--
Critical shear stress (N/m^2)	--	4.79
Apparent velocity (m/s)	--	0.33
Critical depth (m)	0.20	0.19
Critical discharge (m^3/s)	0.190	0.175
Limiting erosion threshold (m^3/s)	**0.175**	
Unitary erosion threshold ($m^3/s/ha$)	**0.00031**	

*Drainage area provided by JFSA (2025)
**Estimated bankfull discharge and velocity calculated from four representative cross-sections

5 Erosion Exceedance Assessment

In support of the proposed Stormwater Management (SWM) plan, an erosion exceedance analysis was completed for the receiving watercourse (CVC, 2015; TRCA, 2012). The application of erosion threshold analysis for evaluating the effectiveness of stormwater management facilities in mitigating changes in downstream erosion potential is a concept developed with support by a co-author of the present report (P. Villard) and detailed in guidelines prepared on behalf of the Credit Valley Conservation Authority and Toronto and Region Conservation Authority and in Villard and Parish (2003).

Under post-development conditions, overland drainage within the Marlborough Creek catchment overlapping with the subject lands will be directed to an on-site SWM facility. This facility will outlet to **Reach MC1**, located 300 m upstream of **Reach MC3**. **Reach MC3** was selected for analysis as results from desktop and field assessments found it to be the most erosion-sensitive and accessible reach downstream of the SWM Pond outlet within the potential zone of impact.

Using the results from the erosion threshold analysis and hydrological simulation modelling provided by JFSA (2025) for existing and proposed conditions, erosion exceedance analyses to evaluate the potential for changes in the amount of erosion within the watercourse were completed with our in-house Erosion Exceedance Model. The most relevant erosion exceedance indices are summarized below:

1) Cumulative time of exceedance (t_{ex})
2) Number of exceedance events

3) Cumulative effective volume (CEV)
4) Cumulative effective work/stream power index (CEWI)

These indices were developed in response to limitations of traditional peak flow-based stormwater design (Villard & Parish, 2003; Villard & Ness, 2006). They have been applied in various southern Ontario Jurisdictions, including Conservation Halton (CH), Toronto Region Conservation Authority (TRCA), Credit Valley Conservation (CVC). These indices, as a product, provide an evaluation of the number of events, as well as the duration and magnitude of sediment transport (Villard & Ness, 2006). We note that the most relevant indicator is the cumulative effective stream power, as it reflects both the duration and magnitude of erosion exceedance events.

Time of exceedance, number of exceedances, average effective discharge, and cumulative effective volume can be calculated from the discharge record and the established critical discharge. The cumulative time of exceedance is simply the summed duration of time where discharge exceeds the established erosion threshold, and the number of exceedances is the count of erosion exceedance events throughout the discharge record. The cumulative time of exceedance simply quantifies the duration that the threshold is exceeded, but does not provide information on the work or erosive force of flows once the thresholds are exceeded (TRCA, 2012). The average effective discharge represents the average magnitude of discharge exceeding the erosion threshold during a given erosion event, whereas the cumulative effective volume represents the total discharge volume that exceeds the erosion threshold throughout the modelled discharge record.

For more relevant indicators, namely the cumulative effective work index, channel hydraulic information is required. Our model applies discharge to a characteristic cross-section. Using a Manning's approach, the discharge at each time step in the continuous hydrological model is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross-sectional geometry and channel roughness. This provides analysis that is site-appropriate and specific.

The post-development hydrological modelling reflects changes to the hydrological regime resulting from the proposed development and includes the implementation of SWM measures. Continuous flow data for **Reach MC3** was modelled by JFSA (2025) using hourly rainfall data, and was provided in the form of continuous annual models for the years 1967-2016 at 5-minute timesteps. The hydrological simulation data for existing and proposed conditions was analyzed to calculate the aforementioned erosion indices. A full series of post- and pre-development hydrographs, overlain with the respective erosion threshold values, are provided in **Appendix F**, for reference.

5.1 Methodology

To calculate erosion indices, both velocity and shear stress were calculated at each time step. Through an iterative process, water depth and velocity were calculated for each discharge passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels. Velocity, U, is calculated for each panel using the Manning's approach, consistent with practices outlined in Chow (1959) and employed in TRCA (2012). This is a conservative approach as it allows dissipation of flood energy in the floodplain.

This is a conservative approach as it allows dissipation of flood energy in the floodplain, reducing overestimation of erosive potential.

The total discharge, Q_T at each time step is based on the summation of the discharge of all panels, Q_i, such that:

$$Q_{T=} \sum Q_i \qquad \text{[Eq. 3]}$$

Each Q_i represents discharge through a panel (which is set at 10 percent of the cross-section). Q_i is defined as:

$$Q_i = U_i w_i d_i \qquad \text{[Eq. 4]}$$

where, U_i, w_i and d_i are velocity, width and depth for each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area (Villard & Parish, 2003).

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate a maximum bed shear stress, $\tau_{o_{\max}}$ based on:

$$\tau_{o_{\max}} = d_{\max}\rho g S \quad \text{[Eq. 5]}$$

where, $d_{\max}$ is the maximum water depth, ρ is water density, g is acceleration due to gravity, and S is the channel slope.

Cumulative total work, ω_{tot} is defined as:

$$\omega_{\text{tot}} = \sum \tau_{0_{\max}} . U_{\text{avg}} . \Delta t \quad \text{[Eq. 6]}$$

where, U_{avg} is average velocity (Q_{tot}/A_{tot}, where A_{tot} is wetted area), while cumulative effective work index (ω_{eff}) is defined by:

$$\omega_{\text{eff}} = \sum \tau - \tau_{cr} . U . \Delta t, \omega < 0 = 0 \quad \text{[Eq. 7]}$$

where, τ_{cr} is the critical shear stress.

Time of exceedance t_{ex} defined as:

$$t_{\text{ex}} = \sum \Delta t \quad \text{for } (Q_T > Q_{\text{threshold}}) \quad \text{[Eq. 8]}$$

where, $Q_{\text{threshold}}$ is the discharge at the erosion threshold.

The cumulative effective volume (CEV) is defined as:

$$\text{CEV} = \sum Q \text{ (for } Q > Q_{threshold}) \quad \text{[Eq. 9]}$$

5.2 Results

Erosion exceedance modelling results indicate that the proposed stormwater management plan effectively mitigates the risk of increases in erosion potential within the receiving watercourse. Results from the continuous hydrological modelling demonstrate a negligible change in erosion potential under post-development conditions. We note that the cumulative effective work index (ωeff; CEWI) is considered the most relevant index with respect to erosion potential, as it reflects both the flow magnitude and exceedance duration of a given erosion event. Results over +/-5% are considered to be significant enough to result in a measurable change in erosion potential within the receiving watercourse. The cumulative effective discharge (CED) indicator is of secondary relevance, representing the total discharge volume exceeding the established critical discharge throughout the modelling record. The pre-development and post-development hydrographs are included in **Appendix F**. **Table 5** summarizes the results of the erosion exceedance assessment based on the continuous streamflow data provided by JFSA (2025).

Table 5: Erosion exceedance results for Reach MC3.

MC3					
Scenario Cumulative (1960-1999)		**CEV (m^3)**	**ω_{eff} (N/m^2)**	**t_{ex} (hrs)**	**# Of Exceedances**
Q_{crit} = 0.175	**(PRE)**	13,476,833	28,542	7,321	591
	(POST)	13,422,290	29,952	8,906	564
	Change (%)	**-0.40**	**4.94**	**21.64**	**-4.57**

The cumulative effective discharge volume (CED) is expected to decrease by less than 1% under post-development conditions, while the cumulative effective work index (CEWI) is expected to increase by 5%. The duration of exceedances will increase moderately to 22%, while the number of exceedance is predicted to decrease by 5%. The observed decrease in the number of exceedances and associated increase in duration is associated with a post-development reduction in peak flow and corresponding increase in drawdown time, as observed in the hydrographs provided in **Appendix F**. Despite the moderate increase in the duration of exceedance events, the two most relevant erosion indices remain within +/-5% of existing conditions under post-development conditions. This demonstrates that the increase in erosion potential within the receiving watercourse is not expected to measurably impact the pattern and rates of erosion within the receiving watercourse. Thus, results from the erosion exceedance modelling demonstrate that the proposed SWM plan is not anticipated to impact Marlborough Creek negatively.

6 Summary

A fluvial geomorphology and erosion assessment was conducted in support of future development at 6038 Ottawa Street located east of the Canadian National Railway in Richmond, Ontario. One (1) SWM Pond is proposed to service the development, discharging to Marlborough Creek, a tributary to the Jock River. Based on results from desktop and field assessments, **Reach MC3** was identified as the most erosion-sensitive reach within the receiving watercourse. A detailed assessment was completed along Reach **MC3** to inform the erosion threshold analysis, which determined a critical discharge of 0.175 m^3/s. Using the defined erosion threshold, an erosion exceedance analysis was completed using modelled stream flow discharge data for long-term continuous hydrological simulations (JFSA, 2025). An evaluation of pre- to post-development erosion metrics indicated that the proposed SWM facilities effectively address any potential erosion risk for the receiving watercourses. The SWM strategy results in no significant change in erosion potential within **MC3**.

We trust this report meets your current requirements. Should you have any questions, please contact us.

Respectfully submitted,

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Director, Principal Geomorphologist

Jan Franssen, Ph.D
Senior Watershed Scientist, Technical Lead

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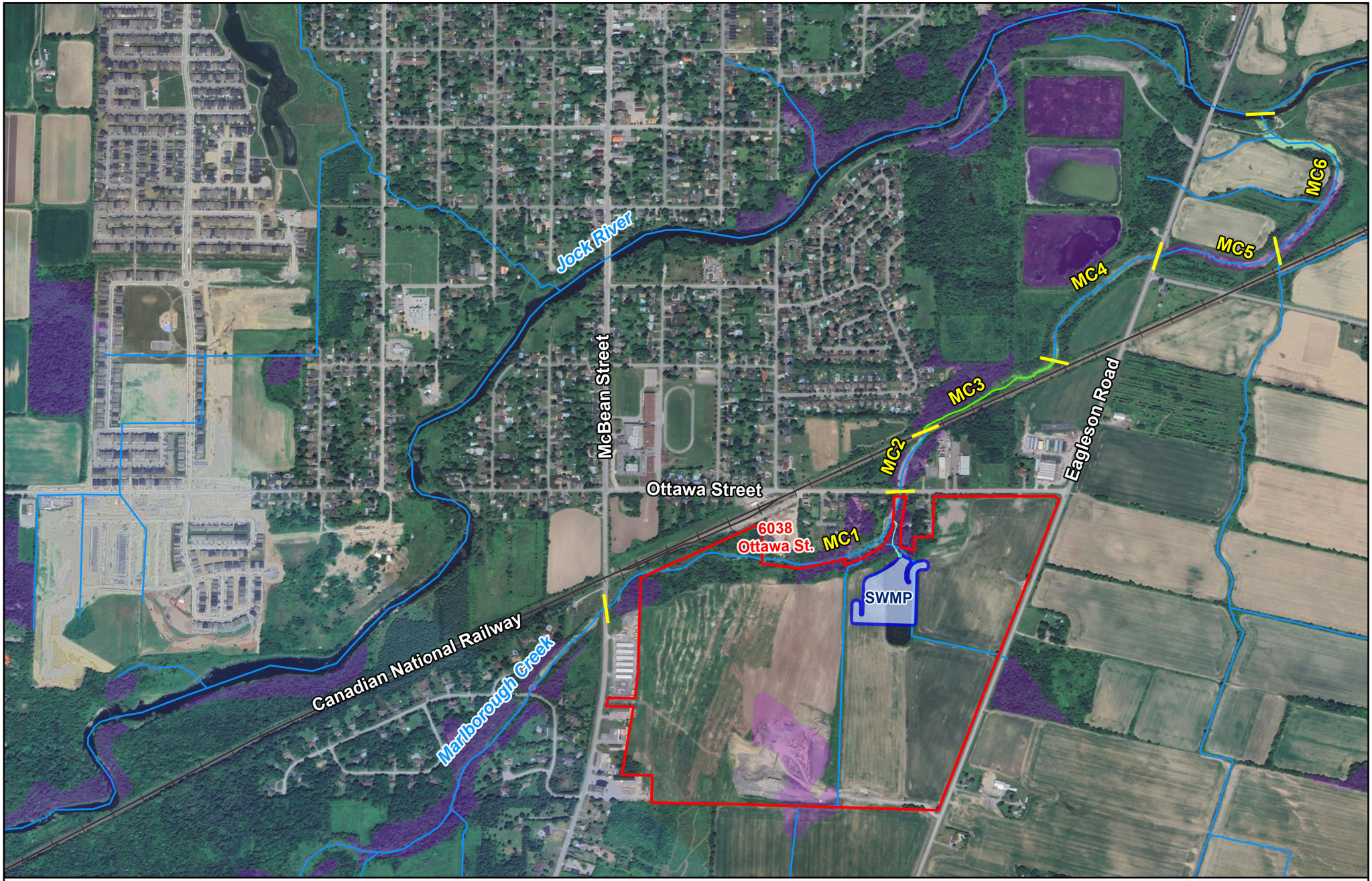
Appendix A:
Site Maps



Legend

- Reach Break and ID
- Railway
- Watercourse
- Detailed Assessment
- Proposed Outlet Channel
- Evaluated Wetland
- Not Evaluated Wetland
- Proposed SWM Pond
- Study Area

Study Area

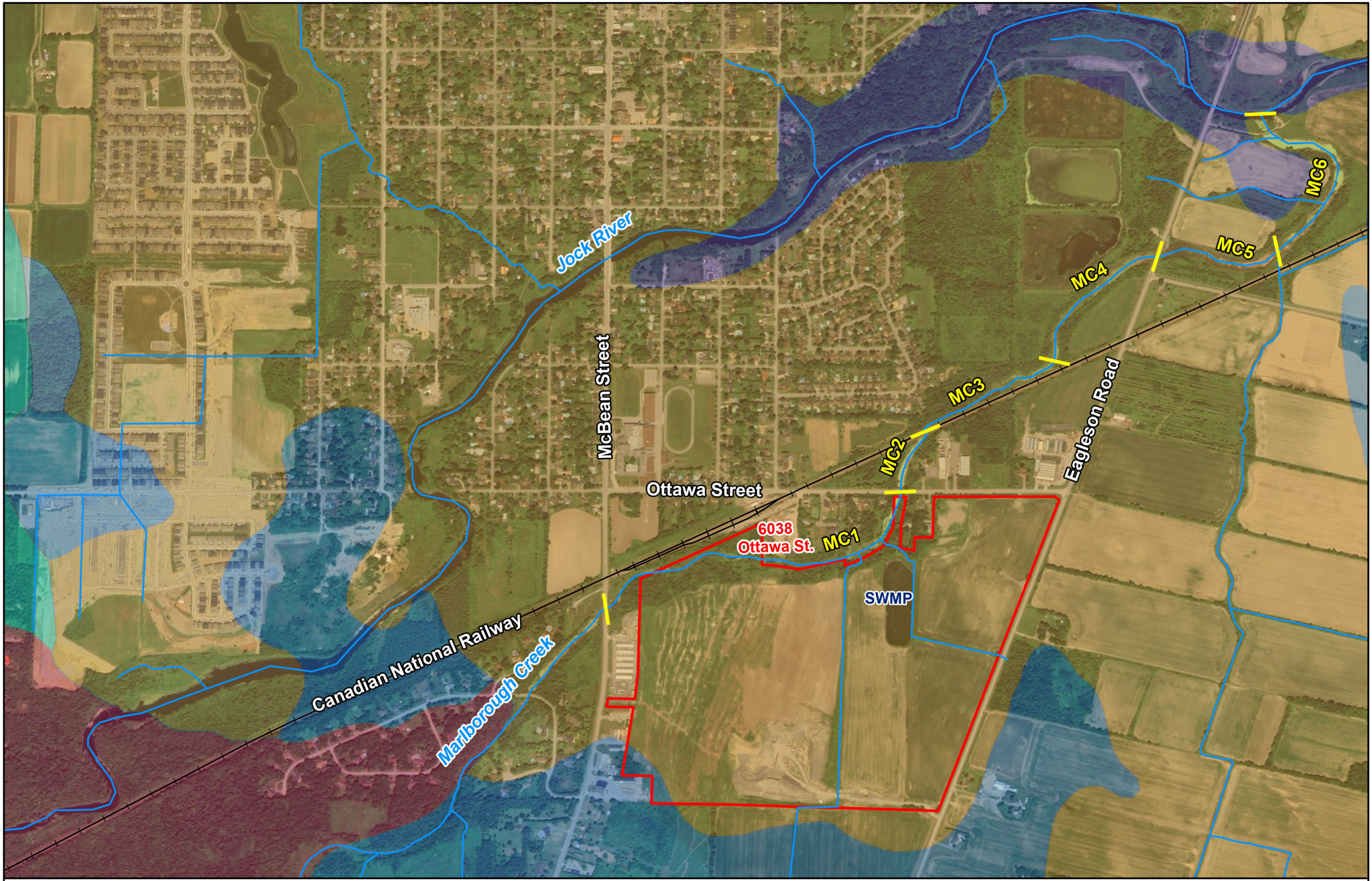
Marlborough Creek

6038 Ottawa Street
Richmond, Ontario

GEO MORPHIX™

0 75 150 300
Metres

Imagery: Google Earth Pro, 2024. Reach Break and ID: GEO Morphix Ltd., 2021/2025. SWMP, Study Area, and Outlet: DSEL, 2021/ 2025. Wetland, Waterbody, Watercourse and Railway: MNRF, 2024/2021.
Printed: October 2025. PN25011. Drawn by: K.W., K.Sm., G.U.



Legend

- Reach Break and ID (MC1)
- Railway
- Watercourse
- Study Area

Surficial Geology

- 10a,Offshore marine deposits (clay, silt)
- 11c,Nearshore sediments (sand)
- 19,Alluvial deposits (clay,silt,sand)
- 20,Organic deposits
- 3,Bedrock (limestone, dolomite)
- 5b,Till (sandy silt diamicton)

Surficial Geology

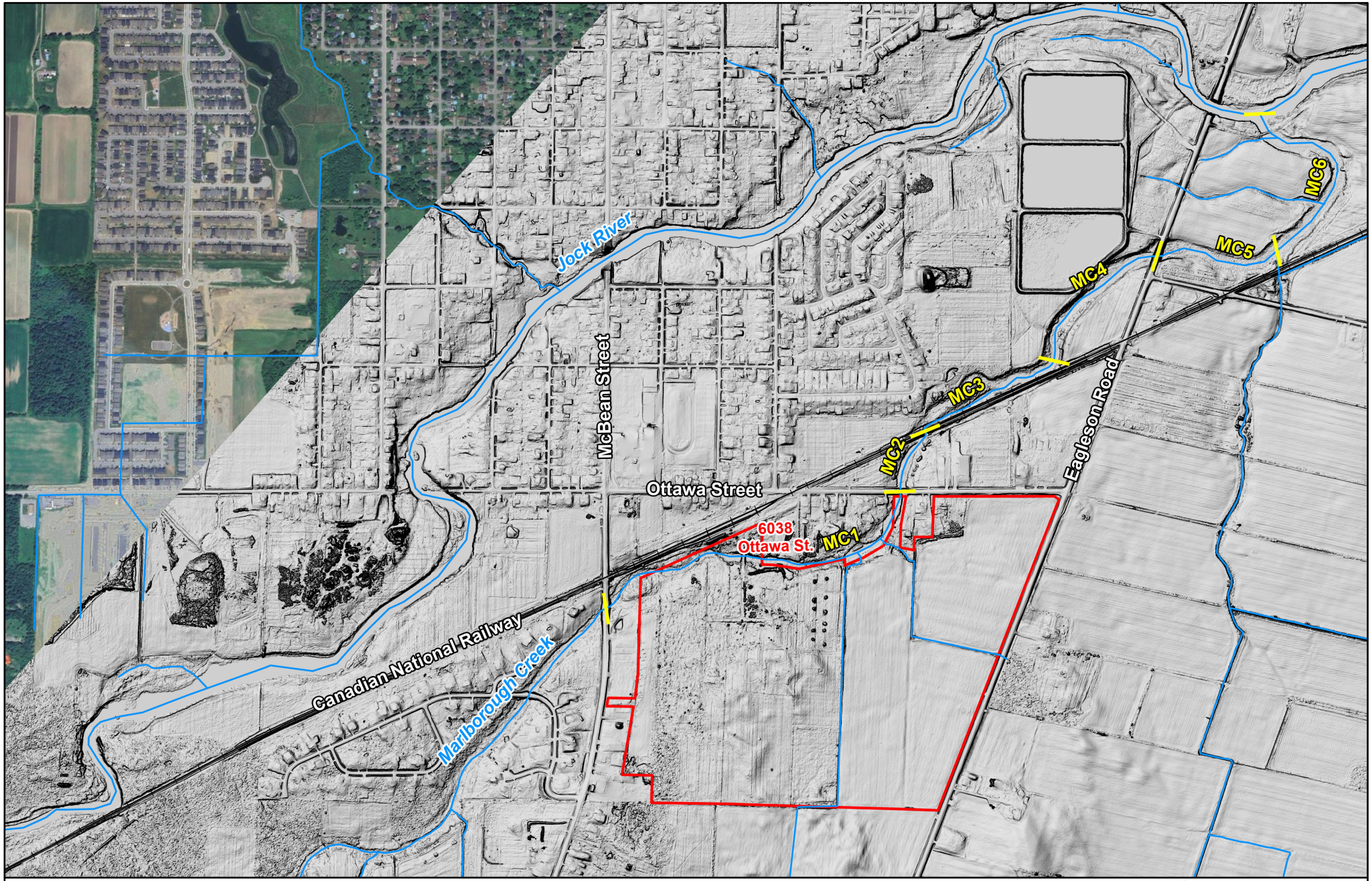
Marlborough Creek

6038 Ottawa Street
Richmond, Ontario

GEO MORPHIX™

0 75 150 300
Metres

Imagery: Google Earth Pro, 2024. Study Area: DSEL, 2025 Reach Break and ID: GEO Morphix Ltd., 2021/2025. SGU, Watercourse and Railway: MNRF, 2024/2021. Printed: October 2025. PN25011. Drawn by: K.W., K.Se., G.U.



Legend

- Reach Break and ID (MC1)
- Railway
- Watercourse
- Study Area

Study Area - Hillshade

Marlborough Creek

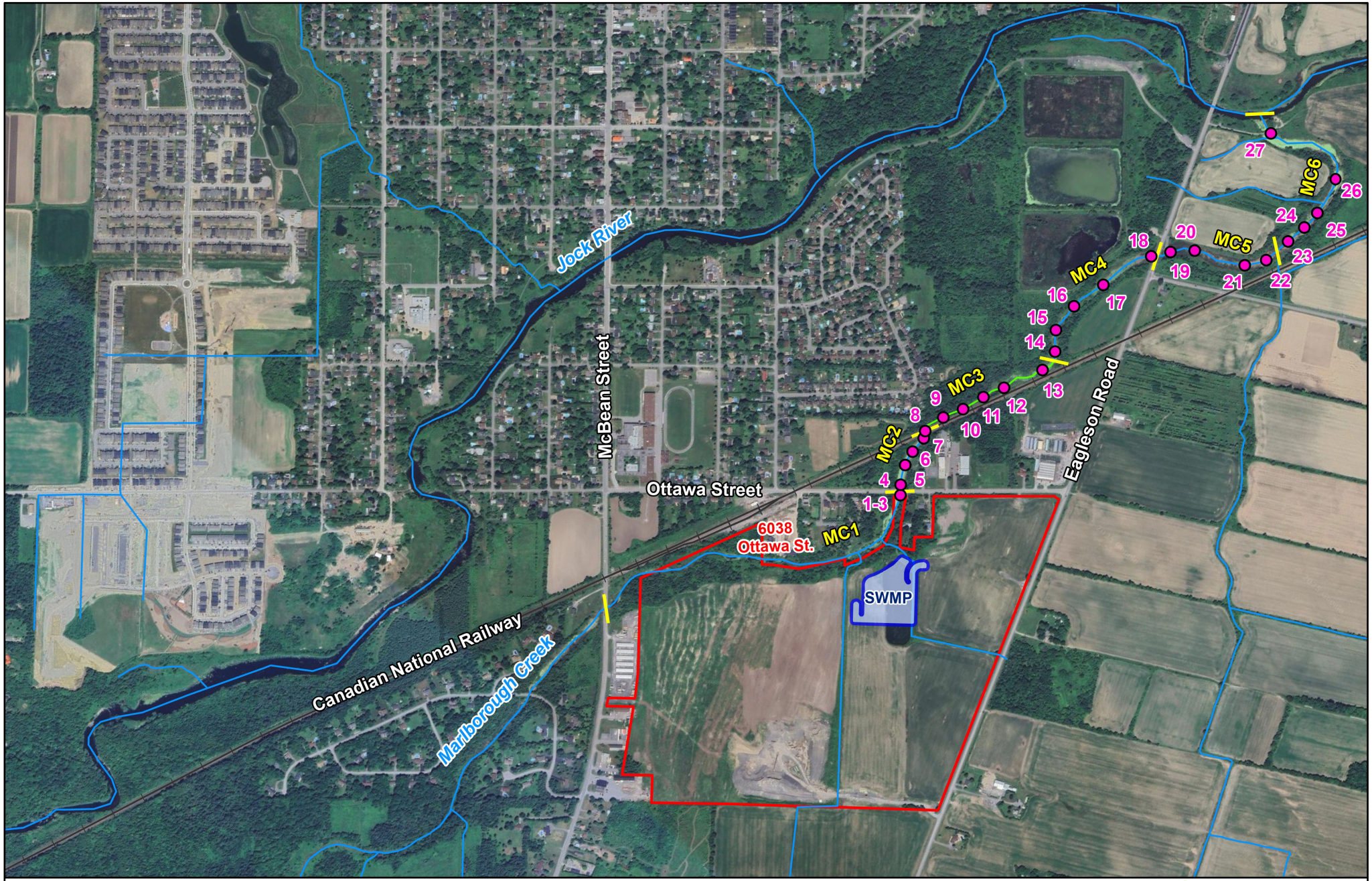
6038 Ottawa Street
Richmond, Ontario

GEO MORPHIX™

0 75 150 300
Metres

Hillshade: MNRF, 2020. Study Area: DSEL, 2025.
Reach Break and ID: GEO Morphix Ltd., 2021/2025.
Watercourse and Railway: MNRF, 2024/2021.PN25011
Printed: October 2025. Drawn by: K.W., K.Sm., G.U.

Appendix B:
Site Photographs



Legend

- Reach Break and ID
- Photo Locations
- Watercourse
- Detailed Assessment
- Railway
- Proposed SWM Pond
- Study Area

Photo Locations

Marlborough Creek

6038 Ottawa Street
Richmond, Ontario

GEO MORPHIX™

0 75 150 300
Metres

Imagery: Google Earth Pro, 2024. Reach Break and ID, Photo Locations: GEO Morphix Ltd., 2021/ 2025. SWMP, Study Area: DSEL, 2021/ 2025. Wetland, Waterbody, Watercourse and Railway: MNRF, 2024/2021. Printed: October 2025. PN25011. Drawn by: K.W., K.Sm., G.U.

Photo 1 **Marlborough Creek** **Reach: MC1**	
	Photograph taken facing upstream from Ottawa street box culvert of reach MC1. Note the fallen trees in the channel and dense floating rooted aquatic vegetation.
Photo 2 **Marlborough Creek** **Reach: MC1**	
	Photograph taken facing upstream from Ottawa street box culvert of reach MC1. Photo showing left bank of channel.

Photo 3 Marlborough Creek Reach: MC1	
	Photograph taken facing upstream from Ottawa street box culvert of reach MC1. Photo showing right bank of channel.
Photo 4 Marlborough Creek Reach: MC2	
	Photograph taken facing downstream from Ottawa Street box culvert of reach MC2. Channel exhibits no flow, lack of riffle-pool morphology, and dense floating rooted aquatic vegetation.

Photo 5 Marlborough Creek Reach: MC2	
	Photograph taken facing downstream along reach MC2. Channel is relatively straight with industrial land use near right bank of reach.
Photo 6 Marlborough Creek Reach: MC2	
	Photograph taken facing downstream along reach MC2. Note photo is taken at single bend in channel before entering reach MC3.

Photo 7 Marlborough Creek Reach: MC2	
	Photograph taken facing downstream along MC2. Note the CN railway marks the reach break between MC2 and MC3.
Photo 8 Marlborough Creek Reach: MC2	
	Photograph taken facing downstream under CN railway bridge marking reach break between MC2 into MC3. Note the reduction in channel width and depth from reach MC2 into MC3.

Photo 9 Marlborough Creek Reach: MC3	
	Photograph taken facing downstream along reach MC3. A small riffle with flowing water was observed at the upstream extent of the reach.
Photo 10 Marlborough Creek Reach: MC3	
	Photograph taken facing downstream along reach MC3. Straightened channel had few fallen trees and heavily vegetated banks with some encroachment into channel.

Photo 11 Marlborough Creek Reach: MC3	
	Photograph taken facing downstream along reach MC3. Channel becomes less vegetated and covered near downstream end of reach. The railway embankment located along MC3's right bank was composed of cobbles, with cobbles of similar shape and size found embedded within the channel bed and bank sediments.
Photo 12 Marlborough Creek Reach: MC3	
	Photograph taken facing downstream along reach MC3. Near the downstream end of the reach the dominant channel riparian vegetation transitions from trees and shrubs to tall grasses and herbaceous plants.

Photo 13 Marlborough Creek Reach: MC3	
	Photograph taken facing downstream along reach MC3. The downstream end of the reach widens and enters large floodplain, channel exhibits swamp/wetland like characteristics with no flow, dense vegetation, and no defined channel.
Photo 14 Marlborough Creek Reach: MC4	
	Photograph taken facing downstream at reach MC4. Note CN railway along right bank. Upstream end of reach exhibits swamp/wetland like characteristics.

Photo 15 Marlborough Creek Reach: MC4	
	Photograph taken facing downstream along reach MC4. Channel is heavily vegetated by cattails and european frogbit. Stagnant water and a deep layer of unconsolidated fine sediments were present throughout the extent of the reach.
Photo 16 Marlborough Creek Reach: MC4	
	Photograph taken facing downstream along reach MC4.

Photo 17 Marlborough Creek Reach: MC4	
	Photograph taken facing downstream along reach MC4. No signs of erosion or bank failures along the channel. Heavily vegetated channel and banks.
Photo 18 Marlborough Creek Reach: MC4	
	Photograph taken facing upstream of reach MC4. Photo taken from Eagleson Road which delineates reach break between MC4 and MC5.

Photo 19 Marlborough Creek Reach: MC5	
	Photograph taken facing upstream of reach MC5. Photo taken from Eagleson Road. Reach has the densest vegetation and widest channel of all assessed reaches.
Photo 20 Marlborough Creek Reach: MC5	
	Photograph taken facing upstream along reach MC5. Reach has dense instream vegetation comprised of cattails and european frogbit. Riparian vegetation is comprised of trees, shrubs, and grasses.

Photo 21 **Marlborough Creek** **Reach: MC5**	
	Photograph taken facing upstream along reach MC5. Open area of channel near the downstream end of reach, with no velocity and low gradient.
Photo 22 **Marlborough Creek** **Reach: MC5**	
	Photograph taken facing upstream of reach MC5. CN railway runs along a portion of the right channel bank. Channel is located on left side of photo.

Photo 23 Marlborough Creek Reach: MC6	
	Photograph taken facing upstream at reach MC6. Start of MC6 and end of MC5, dominant aquatic vegetation changes from cattails to duckweed resulting in more open channel.
Photo 24 Marlborough Creek Reach: MC6	
	Photograph taken facing upstream along reach MC6. Small riffle present at the beginning of reach,; one of few instances of riffle-pool morphology along the entirety of creek.

Photo 25 Marlborough Creek Reach: MC6	
	Photograph taken facing upstream along reach MC6. The channel is bordered by agricultural land on both banks.
Photo 26 Marlborough Creek Reach: MC6	
	Photograph taken facing upstream along reach MC6. The reach is dominated by floating rooted aquatic vegetation. No flow observed and no erosion present as reach has stable banks and low bank angles. The riparian zone at the downstream portion of the reach is bordered by an agricultural access road.

Photo 27 Marlborough Creek Reach: MC6	
	Photograph taken facing upstream at reach MC6. Confluence of Marlborough creek with Jock River, photo taken on agricultural access road which creek flows under.

Appendix C:
Field Sheets

General Site Characteristics

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough Creek
Time:	8:25	**Reach:**	MC2
Weather:	25C overcast	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Features	Monitoring
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland / algae	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

Additional Symbols

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

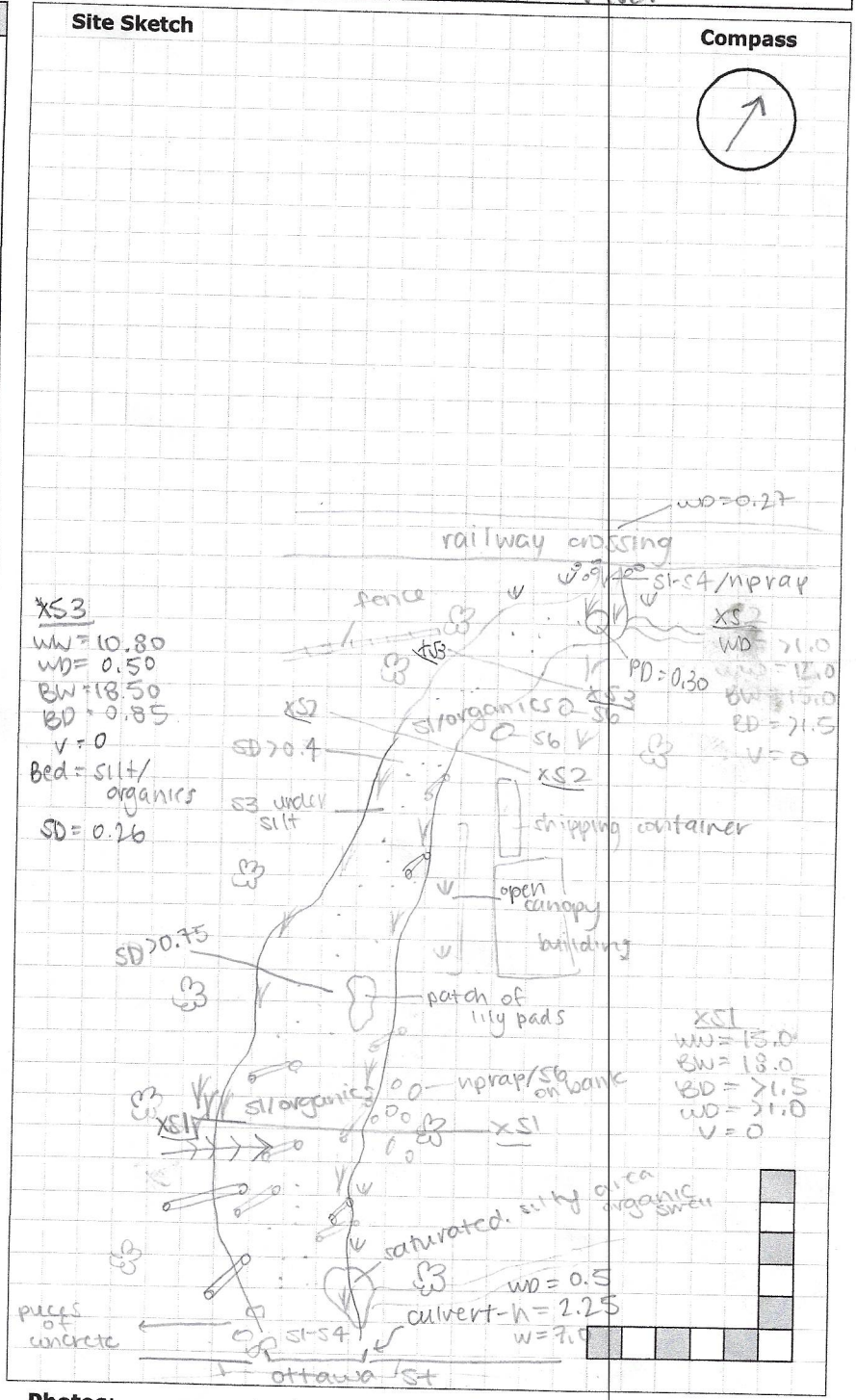
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos: duckweed

Notes: algae/instream veg covers entire reach
substrate generally SI/organics
-woody debris common along banks, banks - SI/S2

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Reach Characteristics Project Number: 25011

Date:	2025-07-08	**Field Staff:**	KC HM	**Watershed/Subwatershed:**	Jock River
Time:	8:25	**Stream:**	Marlborough Creek	**UTM (Upstream):**	
Weather:	25°C overcast	**Reach:**	MC2	**UTM (Downstream):**	

Land Use (Table 1): 4 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 1 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 2 | ☐ Evidence of Groundwater Location:_____ Photo:_____

Riparian Vegetation

Dominant Type (Table 6): 1
Encroachment (Table 7): 2

Coverage	Channel Widths	Age (yrs)
☐ None	☒ 1 - 4	☐ Immature (<5)
☐ Fragmented	☐ 4 - 10	☒ Established (5-30)
☐ Continuous	☐ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 1,3,5
Reach Coverage %: 100

Woody Debris	WD Density
☒ In Cutbank	☒ Low
☐ In Channel	☐ Mod
☐ Not Present	☐ High

WDJ/50m: 1

Water Quality

Odour (Table 16): 6 — organic smell
Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 1
Entrenchment (Table 13): 1
Down's Model (Table 15): D
Sed Sorting (Table 20): well
Transport Mode (Table 21): 3
Geomorphic Units (Table 22): 9
Riffle-Pool Spacing (m): N/A

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14): N/A
Bankfull Indicators (Table 18): 3,5
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: /
Mass Movement (Table 23): N/A
% Riffles: 0 **% Pools:**

Bank Angle	Bank Erosion
☒ 0 – 30	☒ < 5%
☐ 30 – 60	☐ 5 – 30%
☐ 60 – 90	☐ 30 – 60%
☐ Undercut	☐ 60 – 100%

(Table 19)

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☒	☐	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	18.0	15.0	18.50	**Wetted Width (m)**	15.0	12.0	10.80
Bankfull Depth (m)	>1.50	>1.50	0.85	**Wetted Depth (m)**	>1.0	>1.0	0.50
Undercuts (m)	0	0	0	**Velocity (m/s)**	0	0	0
Pool Depth (m)	>1.0			**Velocity Estimate Method**	WB	WB	WB
Riffle Length (m)	N/A			**Meander Amplitude (m)**			

Notes:

wide, stagnant channel with woody debris along banks, silty bed
fully covered by rooted emergent and floating in stream vegetation + floating algae
land use is forest close to channel and industrial beyond
no riffle/pool morphology, 1 flow/depth condition (stagnant)

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX

Rapid Geomorphic Assessment

Project Number: 25011

Date:	2025-07-06	**Stream:**	Marlborough Creek
Time:	8:25	**Reach:**	MC2
Weather:	25°C overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	2/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools	✓		
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials	✓		
	7	Deposition in the overbank zone		✓	
		Sum of indices =	2	5	0.286
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		✓	0/6
	2	Exposed sanitary / storm sewer / pipeline / etc.		N/A	
	3	Elevated storm sewer outfall(s)		N/A	
	4	Undermined gabion baskets / concrete aprons / etc.		N/A	
	5	Scour pools downstream of culverts / storm sewer outlets		N/A	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint migration		✓	
	8	Terrace cut through older bar material		✓	
	9	Suspended armour layer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =	0	6	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		1/7
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle		✓	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		N/A	
	8	Exposed length of previously buried pipe / cable / etc.		✓	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation		N/A	
		Sum of indices =	1	9	0.142
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	0/7
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)		✓	
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	0	7	0

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.107

In Regime	In Transition/Stress	In Adjustment
☑ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough Creek
Time:	8:25	**Reach:**	MC2
Weather:	25°C overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
~no exposed roots	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☒ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11

~no riffles	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
Channel Scouring/ Sediment Deposition	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
~no pbs	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☒ 5 ☐ 6	☐ 7 ☐ 8

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX

Date:	2025-07-08	PN:	25011	Location:	Marlborough Creek

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☒ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☒ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☒ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 20	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM/KC

General Site Characteristics

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	9:00	**Reach:**	MC3
Weather:	25C overcast	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank	er	exposed roots
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland/algae		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

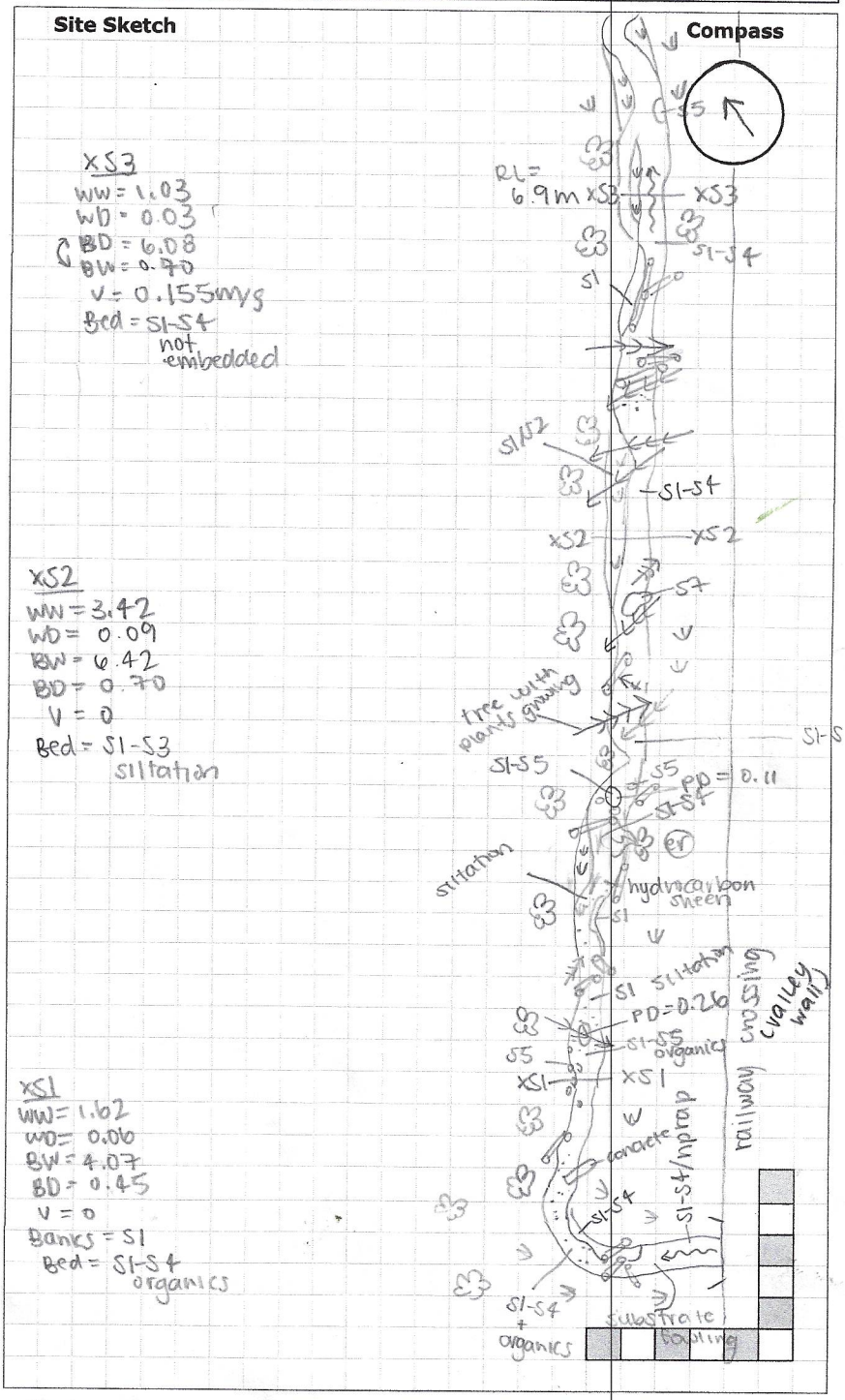
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos:

Notes: minimal bank erosion, siltation observed
limited riffle/pool morphology
duck weed + rooted emergent vegetation common

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

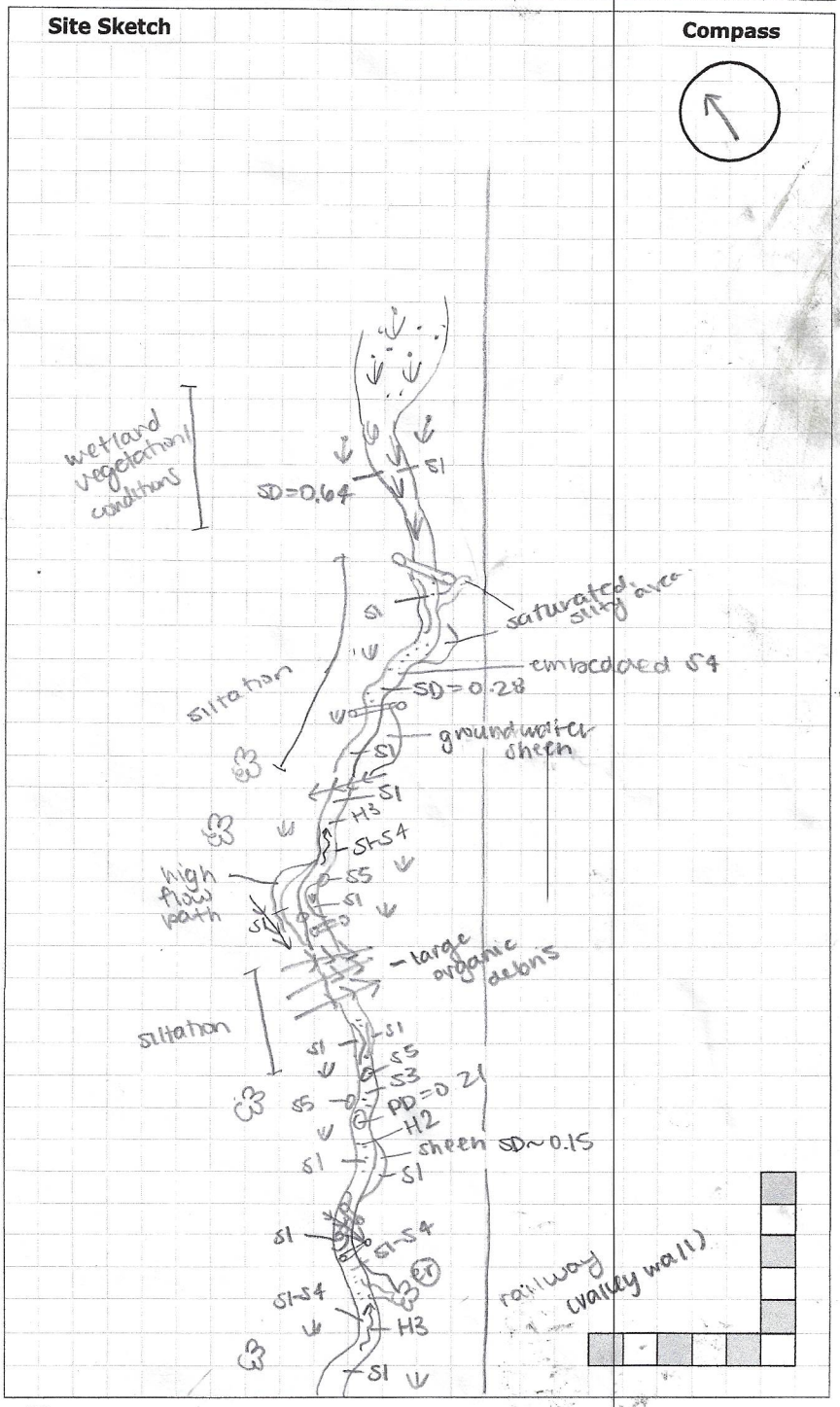
General Site Characteristics

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	9:34	**Reach:**	MC3
Weather:	25c overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	JOCK river

Features	Monitoring
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

Site Sketch



Photos:

Notes:

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

GEO MORPHIX™

Reach Characteristics Project Number: 25011

Date:	2025-07-08	**Field Staff:**	KC HM	**Watershed/Subwatershed:**	Dock River
Time:	9:34	**Stream:**	Harborough Creek	**UTM (Upstream):**	
Weather:	25°C overcast	**Reach:**	MC3	**UTM (Downstream):**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 3 | **Channel Type** (Table 3): 7 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1

☑ Evidence of Groundwater Location: → groundwater sheen on surface Photo: _____

Riparian Vegetation

Dominant Type (Table 6): 1/3

Encroachment (Table 7): 1

Coverage: ☐ None; ☐ Fragmented; ☑ Continuous

Channel Widths: RB ☑ 1 - 4; ☐ 4 - 10; LB ☑ > 10

Age (yrs): ☑ Immature (<5); ☑ Established (5-30); ☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 1,3,5

Reach Coverage %: 85

Woody Debris: ☑ In Cutbank; ☑ In Channel; ☐ Not Present

WD Density: ☐ Low; ☑ Mod; ☐ High

WDJ/50m: 2

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity Type (Table 9): 1

Gradient (Table 11): 1

Entrenchment (Table 13): 1

Down's Model (Table 15): D

Sed Sorting (Table 20): mod

Transport Mode (Table 21): 1,2,3

Geomorphic Units (Table 22): 7,9

Riffle-Pool Spacing (m):

Sinuosity Degree (Table 10): 2

# of Channels (Table 12): 1

Bank Failure (Table 14): 1

Bankfull Indicators (Table 18): 3,5

Sediment Transport Observed? ☐ Yes ☐ No ☑ Not Visible

% of Bed Active: /

Mass Movement (Table 23): N/A

% Riffles: 5 **% Pools:** 5

Bank Angle: ☑ 0 - 30; ☐ 30 - 60; ☐ 60 - 90; ☐ Undercut

Bank Erosion: ☑ < 5%; ☐ 5 - 30%; ☐ 30 - 60%; ☐ 60 - 100%

(Table 19)

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☑	☑	☐	☐	☐	☐	☐
Riffle	☑	☑	☑	☑	☐	☐	☐
Pool	☑	☑	☑	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☐	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	4.07	6.42	6.08	**Wetted Width (m)**	1.62	3.42	1.03
Bankfull Depth (m)	0.45	0.70	0.70	**Wetted Depth (m)**	0.06	0.09	0.03
Undercuts (m)	0	0	0	**Velocity (m/s)**	0	0	0.155
Pool Depth (m)	0.11	0.26		**Velocity Estimate Method**	WB	WB	WB
Riffle Length (m)	6.9			**Meander Amplitude (m)**			

Notes:

generally low, stable banks, 2 instances of exposed mature tree roots, siltation in some areas
- channel bed morphology primarily runs with minimal to no flow, 2 riffles with HB
- riparian vegetation - forested on the left bank, open canopy/grasses on right before railway tracks
  - <4 channel widths between channel and railway, >10 channel widths on left bank
- instream vegetation primarily duck weed, cattails, algae, european frogbit
- substrate ranged from S1-S5, not embedded in riffles, but siltation was noted in some areas

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Rapid Geomorphic Assessment

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marborough Creek
Time:	9:34	**Reach:**	MC3
Weather:	25C overcast	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	KC HM

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		/	2/7
	2	Coarse materials in riffles embedded – 2 riffles, neither embedded		/	
	3	Siltation in pools	/		
	4	Medial bars		/	
	5	Accretion on point bars – pb uncommon		/	
	6	Poor longitudinal sorting of bed materials	/		
	7	Deposition in the overbank zone		/	
		Sum of indices =			0.286
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		/	0/5
	2	Exposed sanitary / storm sewer / pipeline / etc.		N/A	
	3	Elevated storm sewer outfall(s)		N/A	
	4	Undermined gabion baskets / concrete aprons / etc.		N/A	
	5	Scour pools downstream of culverts / storm sewer outlets		N/A	
	6	Cut face on bar forms		/	
	7	Head cutting due to knickpoint migration		/	
	8	Terrace cut through older bar material		/	
	9	Suspended armour layer visible in bank		/	
	10	Channel worn into undisturbed overburden / bedrock		/	
		Sum of indices =			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	/		2/8
	2	Occurrence of large organic debris	/		
	3	Exposed tree roots – 2 instances of mature tree roots		/	
	4	Basal scour on inside meander bends		/	
	5	Basal scour on both sides of channel through riffle		/	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		/	
	8	Exposed length of previously buried pipe / cable / etc.		/	
	9	Fracture lines along top of bank		/	
	10	Exposed building foundation		N/A	
		Sum of indices =			0.25
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		/	0/7
	2	Single thread channel to multiple channel		/	
	3	Evolution of pool-riffle form to low bed relief form		/	
	4	Cut-off channel(s)		/	
	5	Formation of island(s)		/	
	6	Thalweg alignment out of phase with meander form		/	
	7	Bar forms poorly formed / reworked / removed		/	
		Sum of indices =			0

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.134

In Regime	In Transition/Stress	In Adjustment
☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 25011

Date:	2025-07-08	**Stream:**	Harborough Creek
Time:	9:34	**Reach:**	MC3
Weather:	25°C overcast	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Dock River

Category	Poor	Fair	Good	Excellent
generally low, stable banks	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
Channel Stability	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☑ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
-pbs uncommon,	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Date:	2025-07-08	PN:	25011	Location:	Richmond, ON

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☒ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8
Riparian Habitat Conditions (CN Rail on rb; rb narrow and non-woody)	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☒ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 22	Poor (<13)	Fair (13-24) 22	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

General Site Characteristics

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	9:54	**Reach:**	MC4
Weather:	27°c overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock river

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

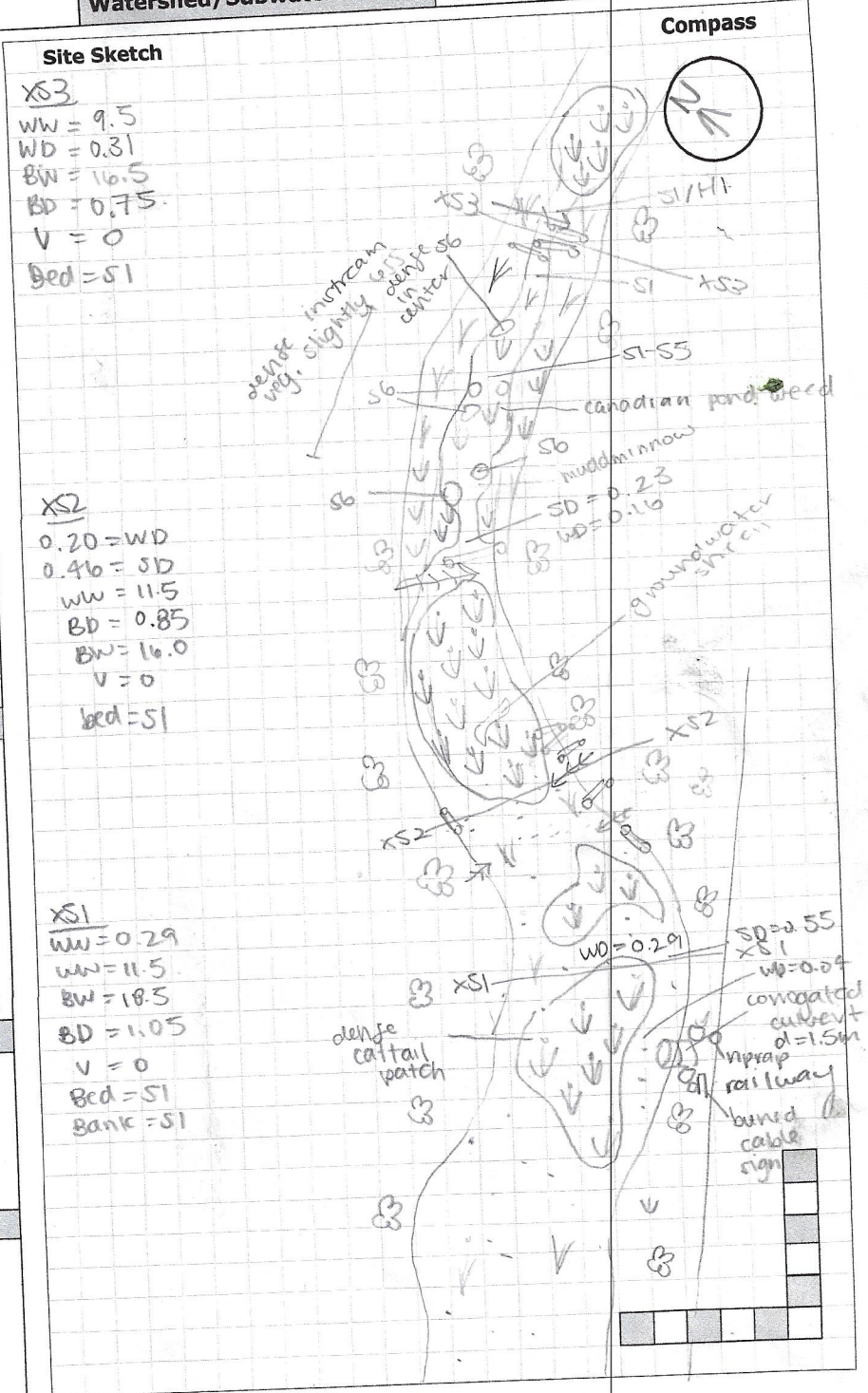
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos:

Notes: swamp/wetland / siltation

rooted emergent wgt algae 100% coverage

woody debris common along stream banks

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

General Site Characteristics

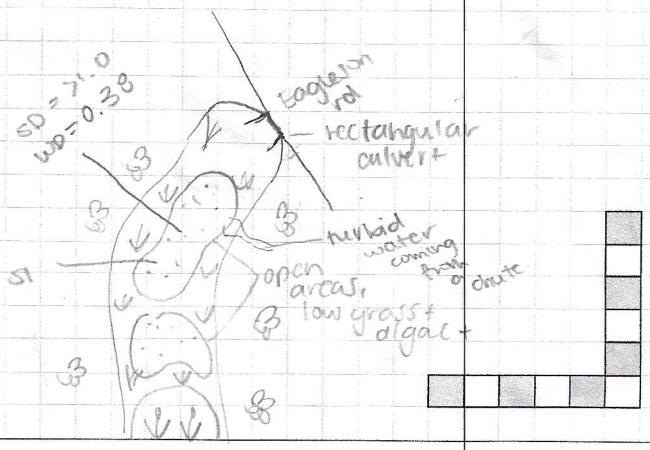
Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	10:36	**Reach:**	MC4
Weather:	27°C overcast,	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	JOCK river

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Site Sketch

Compass



Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Photos:

Notes: mats of lily pad type vegetation in open a

GEO MORPHIX™

Reach Characteristics Project Number: 25011

Date:	2025-07-08	**Field Staff:**	KC HM	**Watershed/Subwatershed:**	Jock River
Time:	9:54	**Stream:**	Marlborough Creek	**UTM (Upstream):**	
Weather:	27°C Overcast	**Reach:**	MC 4	**UTM (Downstream):**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 3 | **Channel Type** (Table 3): 2 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 2 | ☒ Evidence of Groundwater Location: groundwater sheen throughout Photo: ____

Riparian Vegetation

Dominant Type (Table 6): 1
Encroachment (Table 7): 2

Coverage	Channel Widths	Age (yrs)
☐ None	☒ 1 - 4	☐ Immature (<5)
☐ Fragmented	☐ 4 - 10	☒ Established (5-30)
☒ Continuous	☐ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 1,4
Reach Coverage %: 95

Woody Debris	WD Density
☒ In Cutbank	☒ Low
☐ In Channel	☐ Mod
☐ Not Present	☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 6 organic
Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 1
Entrenchment (Table 13): 2
Down's Model (Table 15): D
Sed Sorting (Table 20): 50%
Transport Mode (Table 21): 3
Geomorphic Units (Table 22): 9
Riffle-Pool Spacing (m): \

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14): 1
Bankfull Indicators (Table 18): 3
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: /
Mass Movement (Table 23):
% Riffles: 5 **% Pools:** 95

Bank Angle	Bank Erosion
☒ 0 – 30	☐ < 5%
☐ 30 – 60	☒ 5 – 30%
☐ 60 – 90	☐ 30 – 60%
☐ Undercut	☐ 60 – 100%

(Table 19)

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☐	☐	☐	☐	☐	☐
Riffle	☒	☐	☐	☐	☐	☐	☐
Pool	☒	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☐	☒	☐	☒	☐	☐

Bankfull Width (m)	18.5	16	16.5	**Wetted Width (m)**	11.5	11.5	9.5
Bankfull Depth (m)	1.05	0.85	0.75	**Wetted Depth (m)**	0.29	0.20	0.31
Undercuts (m)	0	0	0	**Velocity (m/s)**	0	0	0
Pool Depth (m)	\	\	\	**Velocity Estimate Method**	\	\	\
Riffle Length (m)	\	\	\	**Meander Amplitude (m)**	\	\	\

Notes:
Channel is primairily straight with slight meander with mainly continous riparian coverage. In channel is heavily vegetated cattail and european frog bit dominated with no velocity, sediment depth regularly exceeds double wetted depth

Photos:

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Rapid Geomorphic Assessment

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	9:54	**Reach:**	MC4
Weather:	27°C overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock river

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	2/7
	2	Coarse materials in riffles embedded – no riffles		✓	
	3	Siltation in pools	✓		
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials	✓		
	7	Deposition in the overbank zone		✓	
		Sum of indices =			0.286
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		✓	0/6
	2	Exposed sanitary / storm sewer / pipeline / etc.		N/A	
	3	Elevated storm sewer outfall(s)		N/A	
	4	Undermined gabion baskets / concrete aprons / etc.		N/A	
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint migration		✓	
	8	Terrace cut through older bar material		✓	
	9	Suspended armour layer visible in bank		N/A	
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		2/8
	2	Occurrence of large organic debris	✓		
	3	Exposed tree roots – uncommon	✓	✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle		✓	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.		✓	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation		N/A	
		Sum of indices =			0.25
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	0/7
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)		✓	
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =			0.

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.124

In Regime	In Transition/Stress	In Adjustment
☑ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM/KC

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	9:54	**Reach:**	MC 4
Weather:	27°C overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock river

Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☒ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Date:	2025-07-08	PN:	25011	Location:	Marlborough creek

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
no riffles	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
- no obs	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☒ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☒ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☒ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 23	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX

General Site Characteristics

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	10:45	**Reach:**	MC5/MC6
Weather:	25C overcast	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

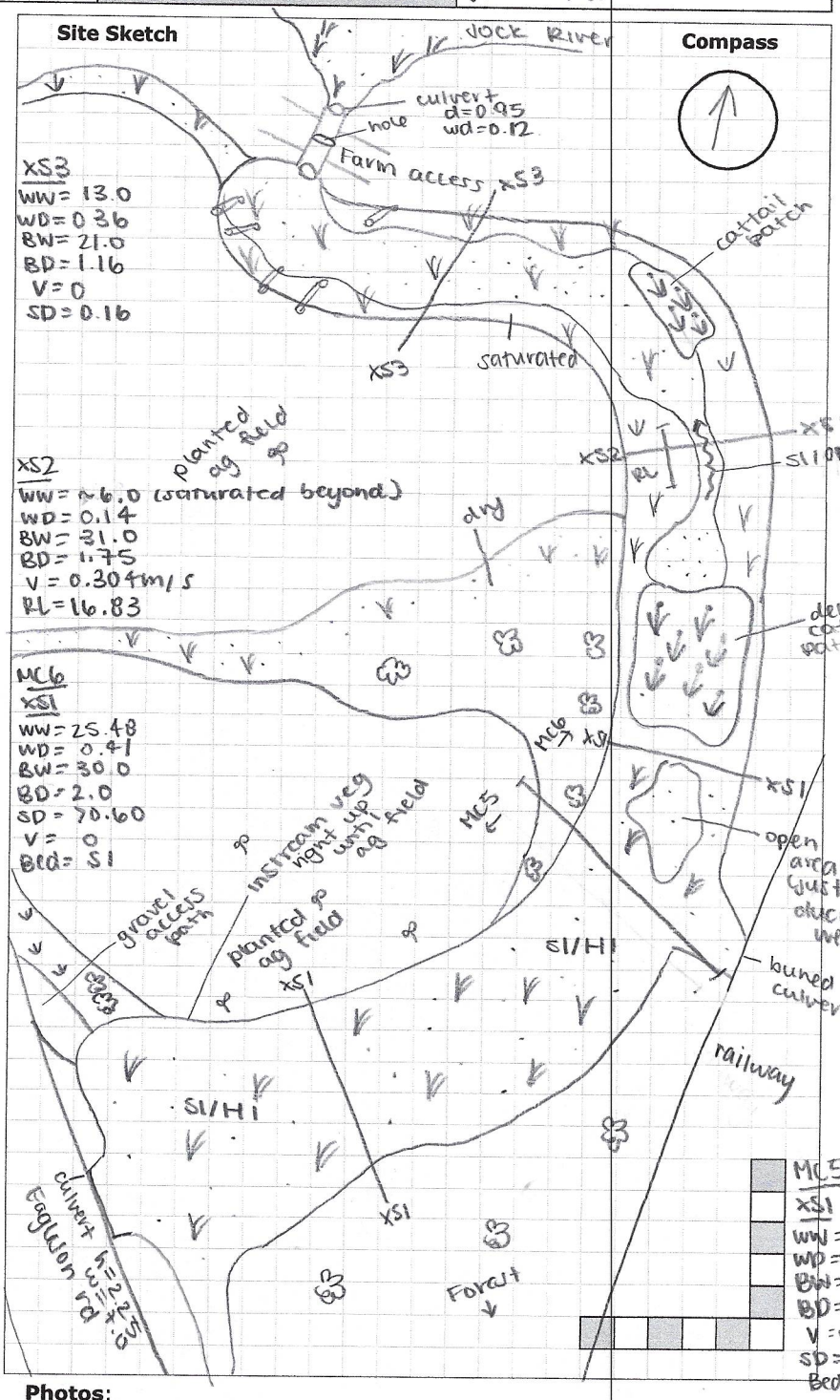
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos:

Notes: MC5: dense rooted emergent veg for entire reach, 100% coverage, siltation throughout

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Reach Characteristics Project Number: 25011

Date:	2025-07-08	**Field Staff:**	KC HM	**Watershed/Subwatershed:**	Dock River
Time:	10:45	**Stream:**	Marborough Creek	**UTM (Upstream):**	
Weather:	overcast 25C	**Reach:**	MC5	**UTM (Downstream):**	

Land Use (Table 1): 3 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 2 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location: _____ Photo: _____

Riparian Vegetation

Dominant Type (Table 6): 1
Encroachment (Table 7): 1

Coverage	Channel Widths	Age (yrs)
☐ None	☒ 1 - 4	☐ Immature (<5)
☒ Fragmented	☐ 4 - 10	☒ Established (5-30)
☐ Continuous	☐ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 1
Reach Coverage %: 100

Woody Debris	WD Density
☐ In Cutbank	☒ Low
☐ In Channel	☐ Mod
☒ Not Present	☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 1
Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 1
Entrenchment (Table 13): 1
Down's Model (Table 15): D
Sed Sorting (Table 20): mod
Transport Mode (Table 21): 3
Geomorphic Units (Table 22): 9
Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14):
Bankfull Indicators (Table 18): 3,5
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: 0
Mass Movement (Table 23): /
% Riffles: 0 **% Pools**: 0

Bank Angle	Bank Erosion
☒ 0 - 30	☒ < 5%
☐ 30 - 60	☐ 5 - 30%
☐ 60 - 90	☐ 30 - 60%
☐ Undercut	☐ 60 - 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☒	☐	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	41.0	**Wetted Width (m)**	31.0		
Bankfull Depth (m)	2.2	**Wetted Depth (m)**	0.49		
Undercuts (m)	0	**Velocity (m/s)**	0		
Pool Depth (m)	/	**Velocity Estimate Method**	WB		
Riffle Length (m)	/	**Meander Amplitude (m)**	/		

Notes:

Riparian conditions: right bank forest, left bank no riparian buffer → ag field
Dense instream, rooted emergent vegetation covers 100% of reach.

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Rapid Geomorphic Assessment

Project Number: 2501

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	10:45	**Reach:**	MC5
Weather:	25C overcast	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		/	1/7
	2	Coarse materials in riffles embedded		/	
	3	Siltation in pools	/		
	4	Medial bars		/	
	5	Accretion on point bars		/	
	6	Poor longitudinal sorting of bed materials		/	
	7	Deposition in the overbank zone		/	
		Sum of indices =			
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		/	0/6
	2	Exposed sanitary / storm sewer / pipeline / etc.		N/A	
	3	Elevated storm sewer outfall(s)		N/A	
	4	Undermined gabion baskets / concrete aprons / etc.		N/A	
	5	Scour pools downstream of culverts / storm sewer outlets		N/A	
	6	Cut face on bar forms		/	
	7	Head cutting due to knickpoint migration		/	
	8	Terrace cut through older bar material		/	
	9	Suspended armour layer visible in bank		/	
	10	Channel worn into undisturbed overburden / bedrock		/	
		Sum of indices =			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		/	0/7
	2	Occurrence of large organic debris		/	
	3	Exposed tree roots		/	
	4	Basal scour on inside meander bends		/	
	5	Basal scour on both sides of channel through riffle		/	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		/	
	8	Exposed length of previously buried pipe / cable / etc.		N/A	
	9	Fracture lines along top of bank		/	
	10	Exposed building foundation		N/A	
		Sum of indices =			0
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		/	0/7
	2	Single thread channel to multiple channel		/	
	3	Evolution of pool-riffle form to low bed relief form		/	
	4	Cut-off channel(s)		/	
	5	Formation of island(s)		/	
	6	Thalweg alignment out of phase with meander form		/	
	7	Bar forms poorly formed / reworked / removed		/	
		Sum of indices =			0

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.14

In Regime	In Transition/Stress	In Adjustment
☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX

Rapid Stream Assessment Technique Project Number: 25011

Date:	2025-07-08	**Stream:**	Marborough Creek
Time:	10:45	**Reach:**	MC5
Weather:	25°C overcast	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Rock River

Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☑ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas) (-no riffles)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand (-no pbs)	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☑ 4	☐ 5 ☐ 6	☐ 7 ☐ 8

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Date:	2025-07-08	PN:	25011	Location:	Richmond, ON

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☒ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☒ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☒ 1	☐ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 20	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Reach Characteristics Project Number: 25011

Date:	2025-07-08	**Field Staff:**	KC HM	**Watershed/Subwatershed:**	Dock River
Time:	10:45	**Stream:**	Marlborough Creek	**UTM (Upstream):**	
Weather:	25°C overcast	**Reach:**	MC6	**UTM (Downstream):**	

Land Use (Table 1): 3 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 2 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1

☒ Evidence of Groundwater Location: ~~throughout~~ groundwater sheen Photo: _____

Riparian Vegetation

Dominant Type (Table 6): 1
Encroachment (Table 7): 2

Coverage	Channel Widths	Age (yrs)
☐ None	☒ 1 - 4	☐ Immature (<5)
☒ Fragmented	☐ 4 - 10	☒ Established (5-30)
☐ Continuous	☐ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 1, 4
Reach Coverage %: 85

Woody Debris	WD Density
☒ In Cutbank	☒ Low
☐ In Channel	☐ Mod
☐ Not Present	☐ High

WDJ/50m: 0.5

Water Quality

Odour (Table 16): 6 organic
Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 1
Gradient (Table 11): 1
Entrenchment (Table 13): 1
Down's Model (Table 15): D
Sed Sorting (Table 20): poor
Transport Mode (Table 21): 3
Geomorphic Units (Table 22): 7, 9
Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 1
# of Channels (Table 12): 1
Bank Failure (Table 14): /
Bankfull Indicators (Table 18): 3, 5
Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible
% of Bed Active: /
Mass Movement (Table 23): /
% Riffles: 5 **% Pools:**

Bank Angle	Bank Erosion
☒ 0 - 30	☒ < 5%
☐ 30 - 60	☐ 5 - 30%
☐ 60 - 90	☐ 30 - 60%
☐ Undercut	☐ 60 - 100%

(Table 19)

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☐	☐	☐	☐	☐	☐
Riffle	☒	☒	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	30.0	31.0	21.0	**Wetted Width (m)**	25.48	~6.0	13.0
Bankfull Depth (m)	2.0	1.75	1.16	**Wetted Depth (m)**	0.41	0.14	0.36
Undercuts (m)	0	0	0	**Velocity (m/s)**	0	0.304	0
Pool Depth (m)	/			**Velocity Estimate Method**	WB	WB	WB
Riffle Length (m)				**Meander Amplitude (m)**			

Notes:

Channel was generally stagnant with deep sediment, frequently 2x wetted depth, 1 instance of a riffle rooted emergent/floating instream vegetation covered most of reach (duck weed, european frogbit, cattails) small culvert under farm crossing before confluence with Dock River (d = 0.95) riparian vegetation limited, ag field beyond

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Rapid Geomorphic Assessment

Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	11:00	**Reach:**	MC 6
Weather:	27°C overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock river

Process	No.	Geomorphological Indicator	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		\	0/7
	2	Coarse materials in riffles embedded		\	
	3	Siltation in pools		\	
	4	Medial bars		\	
	5	Accretion on point bars		\	
	6	Poor longitudinal sorting of bed materials		\	
	7	Deposition in the overbank zone		\	
		Sum of indices =			0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		N/A	0/10
	2	Exposed sanitary / storm sewer / pipeline / etc.		\	
	3	Elevated storm sewer outfall(s)		N/A	
	4	Undermined gabion baskets / concrete aprons / etc.		N/A	
	5	Scour pools downstream of culverts / storm sewer outlets		\	
	6	Cut face on bar forms		\	
	7	Head cutting due to knickpoint migration		\	
	8	Terrace cut through older bar material		\	
	9	Suspended armour layer visible in bank		N/A	
	10	Channel worn into undisturbed overburden / bedrock		\	
		Sum of indices =			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	\		1/7
	2	Occurrence of large organic debris		\	
	3	Exposed tree roots		\	
	4	Basal scour on inside meander bends		\	
	5	Basal scour on both sides of channel through riffle		N/A	
	6	Outflanked gabion baskets / concrete walls / etc.		N/A	
	7	Length of basal scour >50% through subject reach		\	
	8	Exposed length of previously buried pipe / cable / etc.		\	
	9	Fracture lines along top of bank		\	
	10	Exposed building foundation		N/A	
		Sum of indices =			0,14
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		\	0/7
	2	Single thread channel to multiple channel		\	
	3	Evolution of pool-riffle form to low bed relief form		\	
	4	Cut-off channel(s)		\	
	5	Formation of island(s)		\	
	6	Thalweg alignment out of phase with meander form		\	
	7	Bar forms poorly formed / reworked / removed		\	
		Sum of indices =			0

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0,14

In Regime	In Transition/Stress	In Adjustment
☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Rapid Stream Assessment Technique Project Number: 25011

Date:	2025-07-08	**Stream:**	Marlborough creek
Time:	11:00	**Reach:**	MC6
Weather:	27°C overcast	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock river

Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☒ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Date:	2025-07-08	PN:	25011	Location:	Richmond

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☒ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☒ 1	☐ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 24	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

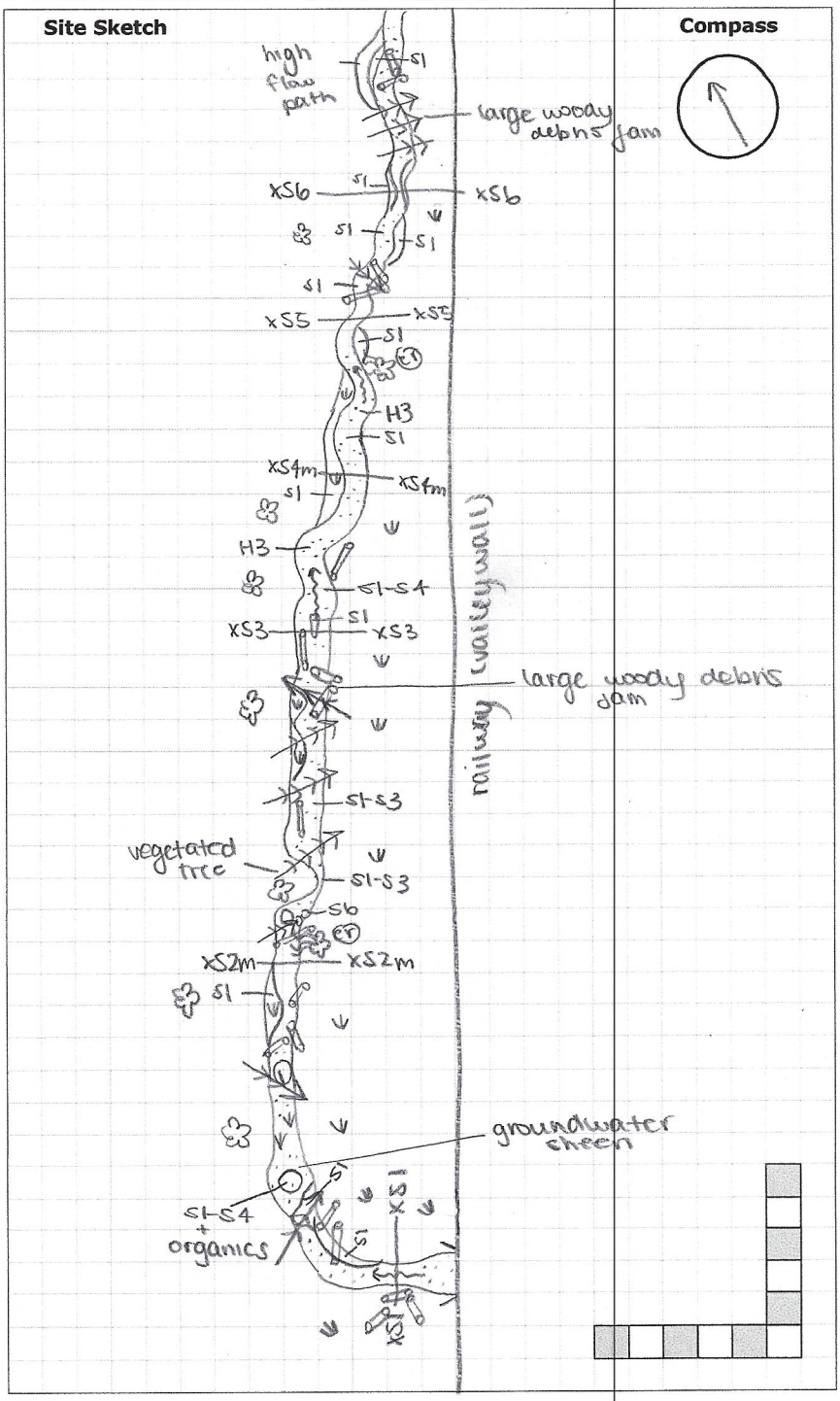
General Site Characteristics

Project Number: 25011

Date:	2025-07-09	**Stream:**	Marlborough Creek
Time:	11:53	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond, ON
Field Staff:	HM KC	**Watershed/Subwatershed:**	Dock River

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Site Sketch



Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Photos:

Notes:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

General Site Characteristics

Project Number: 25011

Date:	2025-07-09	**Stream:**	Marlborough Creek
Time:	12:35	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond, ON
Field Staff:	HM KC	**Watershed/Subwatershed:**	Dock River

Features		Monitoring	
	Reach break		Long-profile
	Station location		Monumented XS
	Cross-section		Monumented photo
	Flow direction		Monumented photo direction
	Riffle		Sediment sampling
	Pool		Erosion pins
	Sediment bar		Scour chains
	Eroded bank/slope	**Additional Symbols**	
	Undercut bank		
	Bank stabilization		
	Leaning tree		
	Fence		
	Culvert/outfall		
	Swamp/wetland/duckweed		
	Grasses		
	Tree		
	Instream log/tree		
	Woody debris		
	Beaver dam		
	Vegetated island		

Flow Type

H1	Standing water	**H1A**	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	**H9A**	Dissipates below free fall

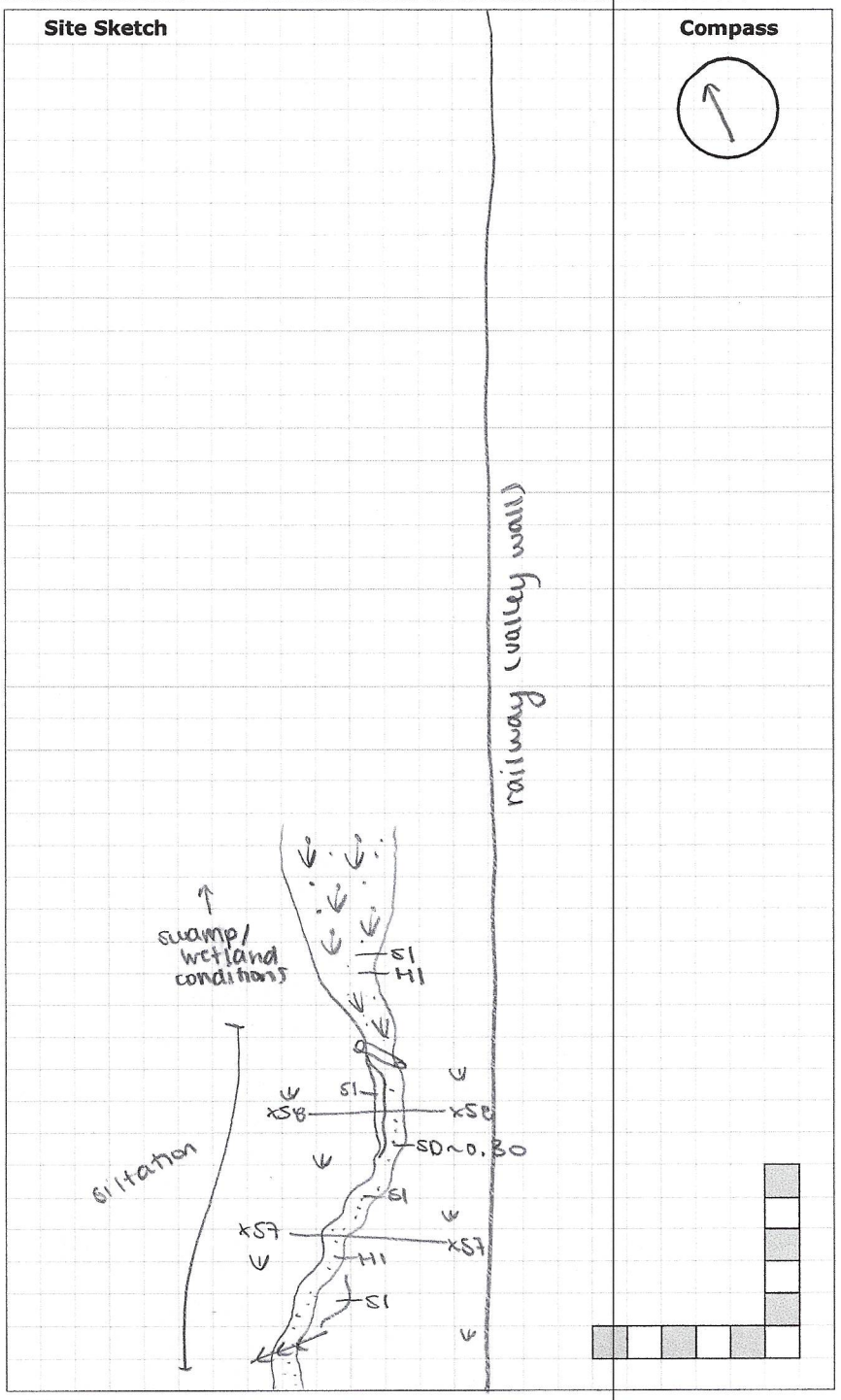
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos:

Notes:

GEO MORPHIX

Detailed Assessment Long Profile (Total Station) **Project Code:** 25011

Date:	2025-07-09	**Reach:**	MC3
Time:	10:48	**Location:**	Richmond
Weather:	Sunny 27°C	**Watershed/Subwatershed:**	Jack River
Field Staff:	KC HM	**Rain in last 24 hours:**	☑ None ☐ Yes: Amount _____ mm

Point No.		Code	Notes
		filename - PN25011	
		long profile starts @ 30,000	
			points 30,089 + 30,090 may need to be removed
		2 - bed	
		1 - WL	

Survey Direction

☑ Upstream to Downstream

☐ Downstream to Upstream

Cross-sections

No. of Cross-sections Surveyed: 8

Monitoring Cross-sections: ☐ No ☑ Yes

XS ID: 2 / 4 / _____

Erosion Pin Installed: ☐ No ☑ Yes

XS ID: 2 / 4 / _____

Velocity & Sediment Transport

☑ Velocity _____ m/s **Method:** see XS

☐ Discharge _____ m^3/s _____

Sed. Transport (Table 21): ☑ Suspended

☐ Saltation ☐ Sliding ☐ Rolling

Percentage of Bed Active: _____ %

Valley Type

☐ Confined ☑ Partially ☐ Unconfined

Channel Zone

☐ Headwater ☑ Transfer ☐ Deposition

Land Use

Forest

Vegetation

Aquatic Vegetation: floating/ rooted emergent

Coverage of Reach: 85 %

☑ In Stream ☑ Margins ☐ On Bank

Riparian Vegetation: ☐ No ☑ Yes

Extent of Riparian Cover:

☐ Fragment ☐ None ☑ Continuous

Riparian Cover (channel widths):

☑ 1-4 RB ☐ 4-10 ☑ >10 LB

Age Class of Riparian Vegetation:

Immature Established Mature

☐ (<5 yrs) ☑ (5-30 yrs) ☐ (>30 yrs)

Extent of Encroachment:

☐ None ☑ Minimal ☐ Moderate

☐ Heavy ☐ Extreme

Density of Woody Debris:

☐ Low ☑ Moderate ☐ High

Blockage(s) in Channel:

☐ Infrastructure ☐ Dam ☐ LWD

GEO MORPHIX™

Detailed Cross-Section Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS1
Time:	10:56	**Reach:**	MC3
Weather:	Sunny 27°C	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

					Notes
RTK					
filename - PN25011					
	points	start	@ 100		

Cross-sectional Morphology (Table 22)

☑ Riffle ☐ Pool ☐ Run ☐ Other

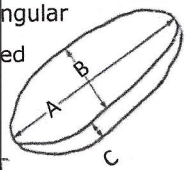
Substrate Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☑ None

Pebble Count Measurements A/B/C Axes (cm):

	A	B	C	A	B	C	A	B	C	A	B	C
Fines				4.3			0.2			7.4		
2				3.3			0.2			10.0		
3				0.5			4.9			0.2		
4	4	4	4	3.0	2.5	1.5	1.0	0.5	0.2	4.9	3.0	1.2
5				2.6			1.4			0.2		
6				5.0			1.1			4.5		
7				4.6			2.1			5.1		
8	8	8	8	5.1	4.0	1.6	6.0	4.2	2.0	5.6	4.2	1.9
9				3.1			4.1			0.2		
10				0.3			3.9			4.8		

Particle Shape: ☐ Platy ☐ Very Angular
☑ Sub-angular ☑ Angular ☐ Rounded
☐ Sub-Rounded ☐ Well Rounded



[Pebble ABC axis guide]

Embededness (%): 35

Subpavement: glaciomarine deposits

Parent Material Bed Coverage (%) 0

Sorting (Table 20): ☐ Well ☐ Moderate ☑ Poor ☐ Very poor

Sediment Transport

☑ Obsv ☐ Not Obsv ☐ Not Visible - Reason: _____

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☑ Saltation

Percentage of Bed Active (%): 5

Velocity

☑ Measured 0.073 m/s Method: WB

☐ Estimated _____ m/s XS ID: XS1

Distance 0.5 m Time 6.86 s V 0.073 m/s

Distance 0.5 m Time 6.78 s V 0.074 m/s

Distance 0.5 m Time 7.05 s V 0.071 m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

Version #4
Last edited: 2025-03-04

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

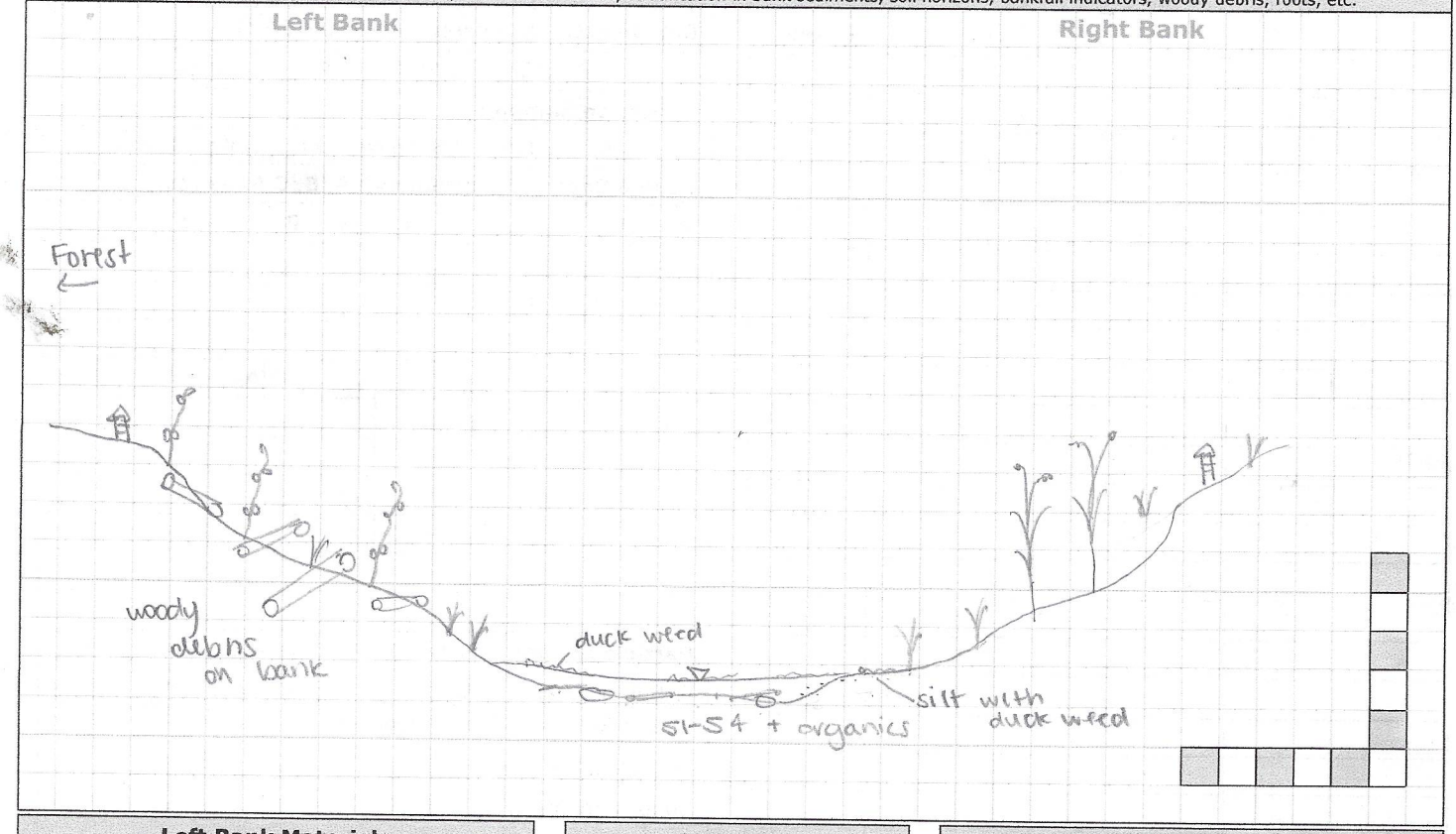
GEO MORPHIX

Bank Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS1
Time:	10:56	**Reach:**	MC3
Weather:	sunny 27°C	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☑ Clay	☐ Large Cobble		
☑ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	0.62	m	
Bank Angle:	15	°	
Root Depth:	0.10	m	
Root Density:	15	%	
Undercut:	0	m	
Erosion Pin:	/	m	
Torvane:	1.0	kg/cm²	
Penetrometer:	0.25	kg/cm²	
Foot Used:	☐ Yes ☑ No		

Features

	Station location
	Monumented XS
	Monumented photo
------	Undercut bank
//////	Eroded bank/slope
	Bank stabilization
x-x-x	Fence
	Grasses
	Leaning tree
	Tree
	Woody Debris
	Sediment sample
	Erosion pin
	Scour/bed chain

Right Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☑ Clay	☐ Large Cobble		
☑ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	0.79	m	
Bank Angle:	25	°	
Root Depth:	0.20	m	
Root Density:	15	%	
Undercut:	0	m	
Erosion Pin:	/	m	
Torvane:	1.0	kg/cm²	
Penetrometer:	0.5	kg/cm²	
Foot Used:	☐ Yes ☑ No		

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Detailed Cross-Section Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS2, monumented
Time:	11:41	**Reach:**	MC3
Weather:	sunny 27C	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

					Notes
RTK					
filename - PN25011					
points start @ 200					

Cross-sectional Morphology (Table 22)

☑ Riffle ☐ Pool ☐ Run ☐ Other

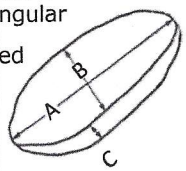
Substrate Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☑ None

Pebble Count Measurements A/B/C Axes (cm):

A	B	C	A	B	C	A	B	C	A	B	C
1			11			4.9			0.4		
2			12			3.1			8.9		
3			13			0.9			2.6		
4	4	4	14	14	14	1.0	0.8	0.6	2.2	1.1	0.6
5			FINES			4.2			2.1		
6			2.4			2.0			0.5		
7			4.0			2.2			0.7		
8	8	8	1.6	1.1	0.5	2.1	2.0	1.3	1.1	0.7	0.5
9			0.5			0.5			1.6		
10			0.7			0.3			2.8		

Particle Shape: ☐ Platy ☐ Very Angular ☑ Sub-angular ☐ Angular ☐ Rounded ☑ Sub-Rounded ☐ Well Rounded



[Pebble ABC axis guide]

Embededness (%): 50

Subpavement: glaciomarine deposits

Parent Material Bed Coverage (%) 0

Sorting (Table 20): ☐ Well ☐ Moderate ☑ Poor ☐ Very poor

Sediment Transport

☐ Obsv ☑ Not Obsv ☐ Not Visible - Reason: no flow

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active (%): _____

Velocity

☐ Measured _____ m/s Method: _____

☐ Estimated _____ m/s XS ID: standing water

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

Version #4
Last edited: 2025-03-04

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

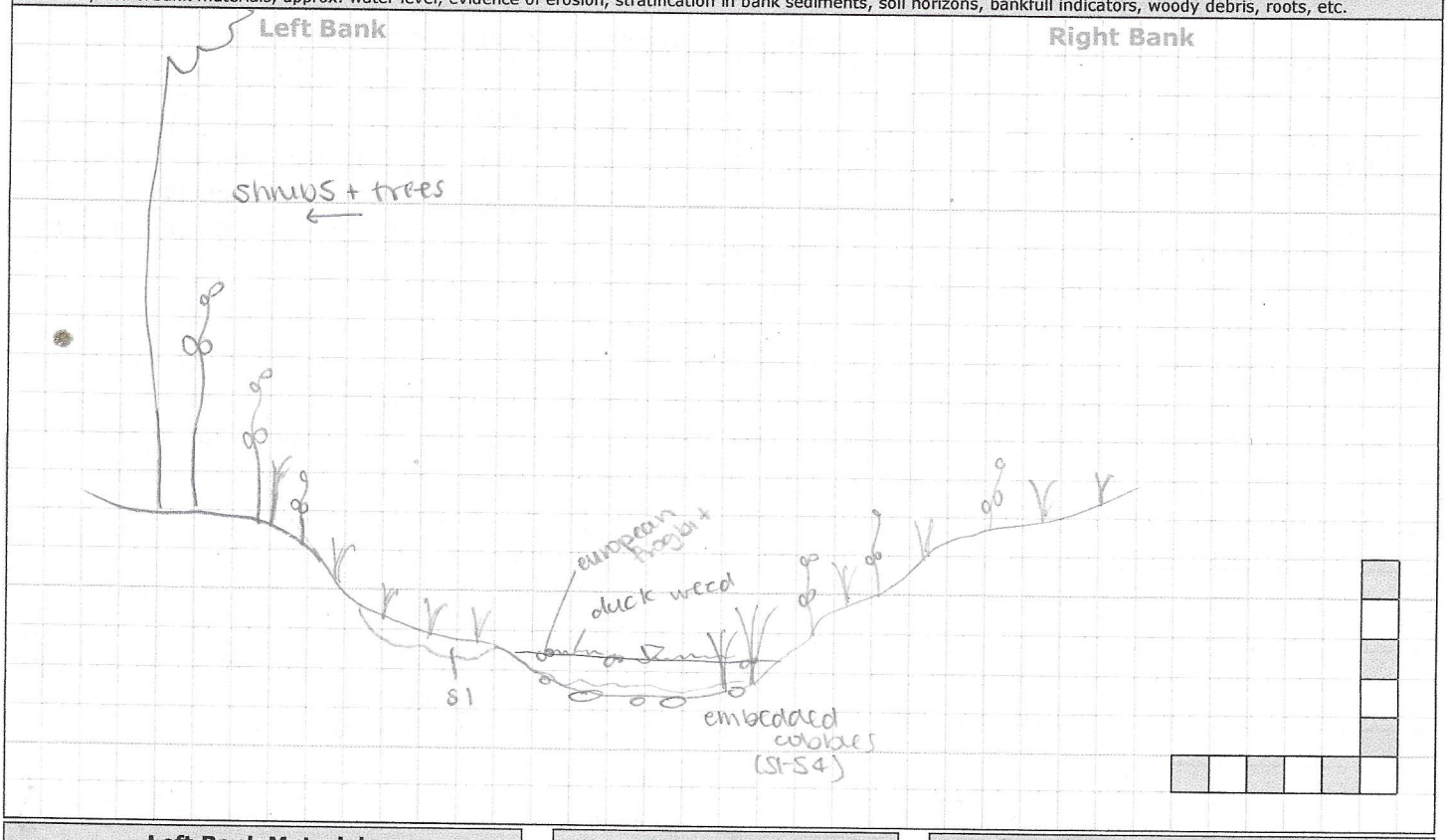
GEO MORPHIX™

Bank Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS2, monumented
Time:	11:41	**Reach:**	MC3
Weather:	28°C sunny	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Rock River

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☑ Clay	☐ Large Cobble		
☑ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	0.65	m	
Bank Angle:	10	°	
Root Depth:	0.15	m	
Root Density:	30	%	
Undercut:	0	m	
Erosion Pin:	~~*~~ 0.2	m	
Torvane:	1.0	kg/cm²	
Penetrometer:	0.25	kg/cm²	
Foot Used:	☐ Yes ☑ No		

Features

	Station location
	Monumented XS
	Monumented photo
------	Undercut bank
#####	Eroded bank/slope
XXXXX	Bank stabilization
x-x-x	Fence
	Grasses
	Leaning tree
	Tree
	Woody Debris
	Sediment sample
	Erosion pin
	Scour/bed chain

Right Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☑ Clay	☐ Large Cobble		
☑ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	0.82	m	
Bank Angle:	35	°	
Root Depth:	0.20	m	
Root Density:	20	%	
Undercut:	0	m	
Erosion Pin:	~~*~~ 0.2	m	
Torvane:	1.0	kg/cm²	
Penetrometer:	0.25	kg/cm²	
Foot Used:	☐ Yes ☑ No		

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Detailed Cross-Section Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS3
Time:	14:59	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Dock River

					Notes
	RTK	PT	300		

Cross-sectional Morphology (Table 22)

☐ Riffle ☐ Pool ☒ Run ☐ Other

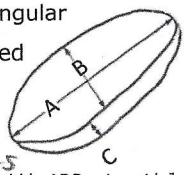
Substrate Sample:

☒ Bed ☒ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count Measurements A/B/C Axes (cm):

A	B	C	A	B	C	A	B	C	A	B	C
8.5											
7.2											
6.3											
7.4	7.1	5.5									
6.8											
fines											

Particle Shape: ☐ Platy ☐ Very Angular ☒ Sub-angular ☐ Angular ☐ Rounded ☐ Sub-Rounded ☐ Well Rounded



[Pebble ABC axis guide]

Embededness (%): 20

Subpavement: glaciomarine deposits

Parent Material Bed Coverage (%) 0

Sorting (Table 20): ☐ Well ☐ Moderate ☒ Poor ☐ Very poor

Sediment Transport

☐ Obsv ☒ Not Obsv ☐ Not Visible - Reason: _____

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active (%): _____

Velocity

☒ Measured 0.069 m/s Method: VM3

☐ Estimated _____ m/s XS ID: XS3

Distance 0.5 m Time 6.80 s V 0.074 m/s

Distance ↓ m Time 7.14 s V 0.070 m/s

Distance ↓ m Time 7.85 s V 0.064 m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

Version #4
Last edited: 2025-03-04

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

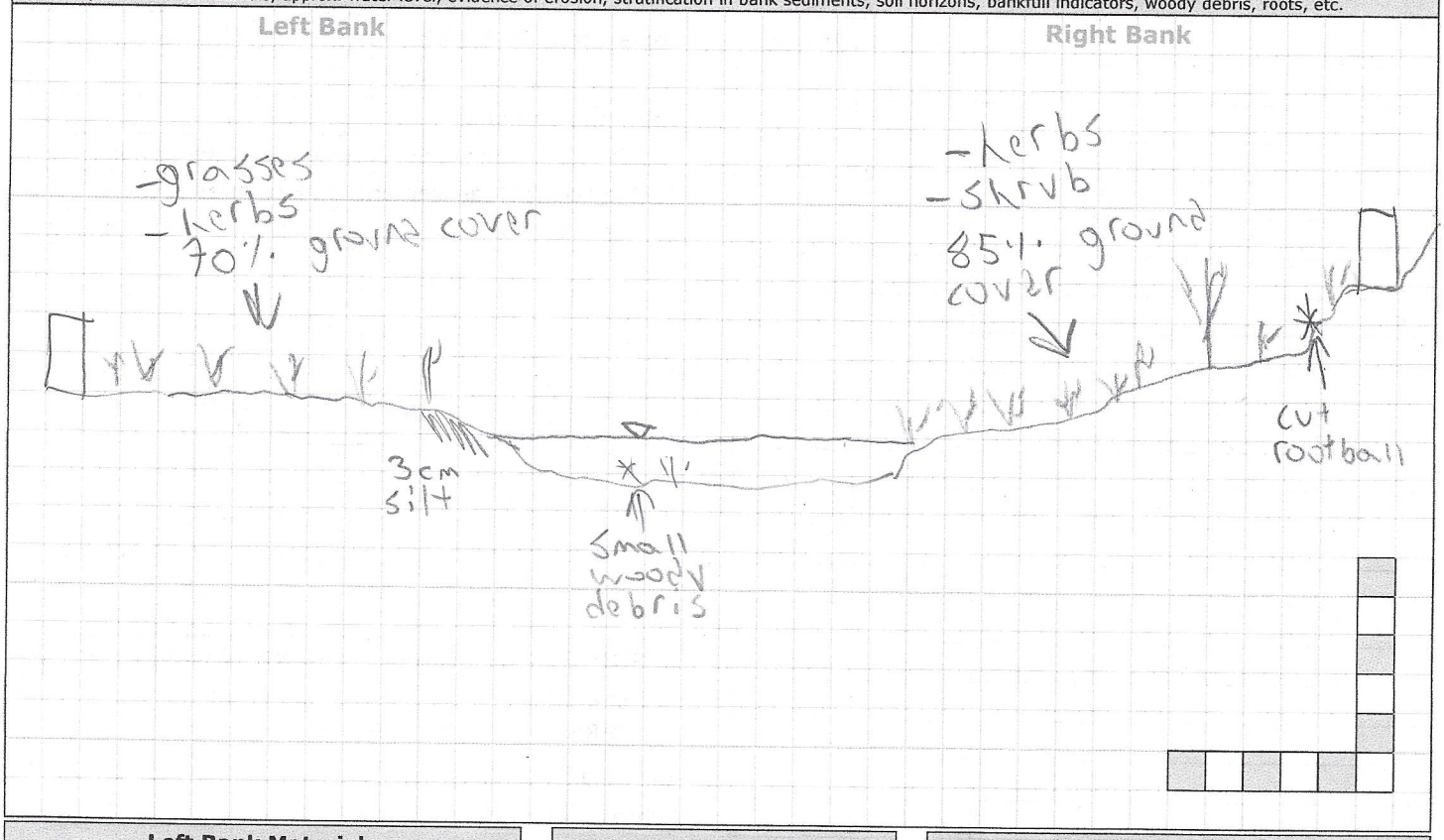
GEO MORPHIX

Bank Characteristics

Project Number:

Date:	2025-07-09	**Cross-section:**	XS3
Time:	14:59	**Reach:**	MC3
Weather:	Sunny 28°C	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☐ Clay	☐ Large Cobble		
☒ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	0.5	m	
Bank Angle:	15	°	
Root Depth:	0.05	m	
Root Density:	10	%	
Undercut:	0	m	
Erosion Pin:	/	m	
Torvane:	0	kg/cm²	
Penetrometer:	0.25	kg/cm²	
Foot Used:	☐ Yes ☒ No		

Features

	Station location
	Monumented XS
	Monumented photo
------	Undercut bank
#####	Eroded bank/slope
XXXXX	Bank stabilization
x-x-x	Fence
	Grasses
	Leaning tree
	Tree
	Woody Debris
	Sediment sample
	Erosion pin
	Scour/bed chain

Right Bank Materials

☐ Bedrock	☒ Gravel		
☐ Till	☐ Small Cobble		
☐ Clay	☐ Large Cobble		
☒ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	2	m	
Bank Angle:	25	°	
Root Depth:	0.07	m	
Root Density:	15	%	
Undercut:	0	m	
Erosion Pin:	/	m	
Torvane:	0	kg/cm²	
Penetrometer:	0.5	kg/cm²	
Foot Used:	☐ Yes ☒ No		

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX

Detailed Cross-Section Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS4-U, Monumented
Time:	12:01	**Reach:**	MC3
Weather:	27°C Sunny	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

					Notes
RTK					

Cross-sectional Morphology (Table 22)

☐ Riffle ☐ Pool ☑ Run ☐ Other

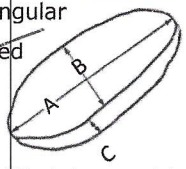
Substrate Sample:

☑ Bed ☑ Bank ☐ Subpavement ☐ Water ☐ None

Pebble Count Measurements A/B/C Axes (cm):

A	B	C	A	B	C	A	B	C	A	B	C
									31		
										Fines.	
									33		
4	4	4	14	14	14	24	24	24	34	34	34
									35		
									36		
									37		
8	8	8	18	18	18	28	28	28	38	38	38
									39		
									40		

Particle Shape: ☐ Platy ☐ Very Angular ☐ Sub-angular ☐ Angular ☐ Rounded ☐ Sub-Rounded ☐ Well Rounded



[Pebble ABC axis guide]

Embededness (%): _____

Subpavement: _____

Parent Material Bed Coverage (%) _____

Sorting (Table 20): ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Obsv ☒ Not Obsv ☐ Not Visible - Reason: _____

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active (%): _____

Velocity

☑ Measured 0.091 m/s Method: WB

☐ Estimated _____ m/s XS ID: XS4

Distance 0.5 m Time 5.13 s V 0.097 m/s

Distance 0.5 m Time 6.45 s V 0.078 m/s

Distance 0.5 m Time 5.17 s V 0.097 m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

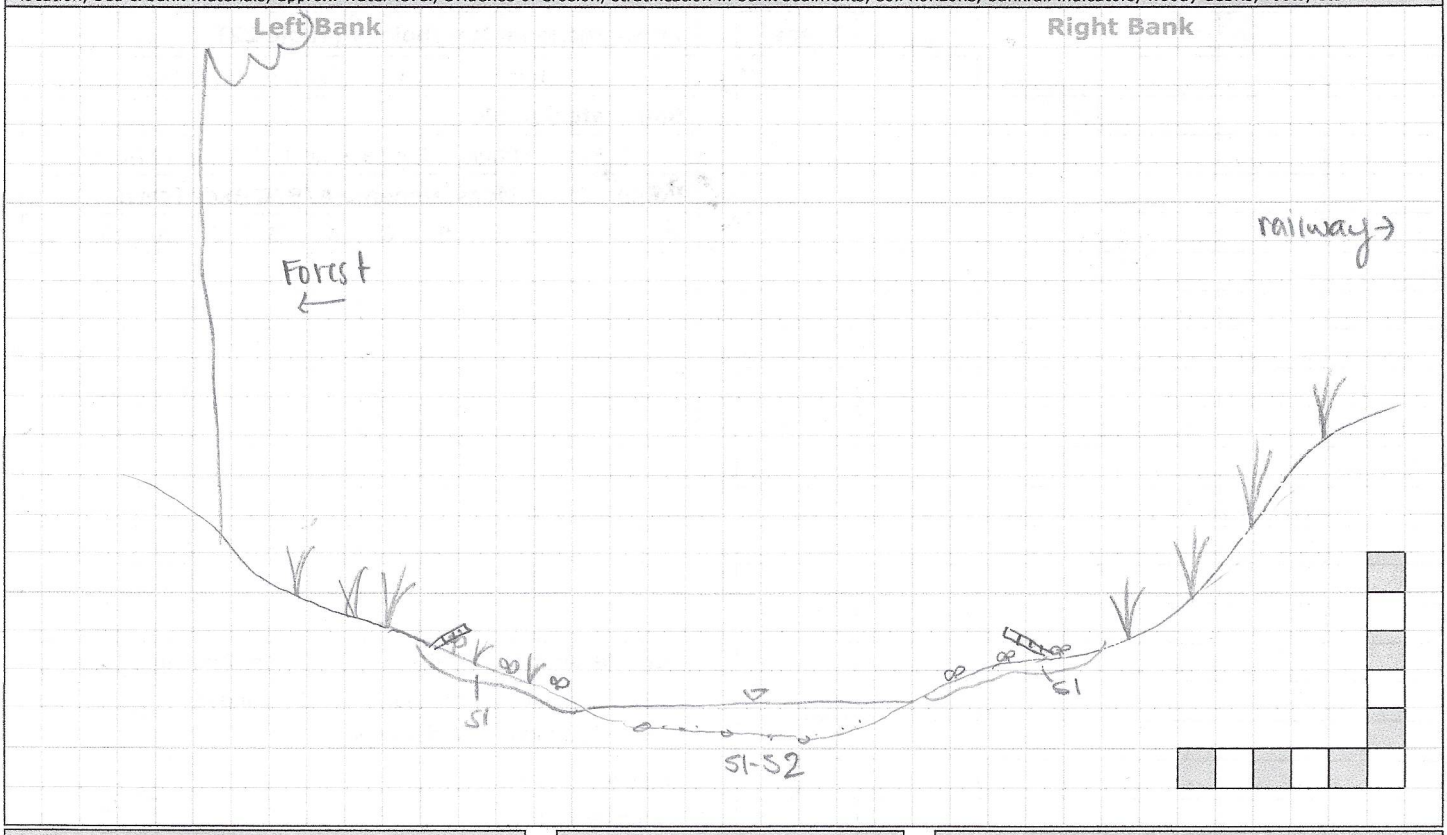
GEO MORPHIX

Bank Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS4, MONUMENTED
Time:	12:01	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond, ON
Field Staff:	KC MM	**Watershed/Subwatershed:**	DOCK RIVER

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials			Features		Right Bank Materials		
☐ Bedrock	☐ Gravel			Station location	☐ Bedrock	☐ Gravel	
☐ Till	☐ Small Cobble			Monumented XS	☐ Till	☐ Small Cobble	
☐ Clay	☐ Large Cobble			Monumented photo	☐ Clay	☐ Large Cobble	
☑ Silt	☐ Small Boulder		------	Undercut bank	☑ Silt	☐ Small Boulder	
☐ Sand	☐ Large Boulder		#####	Eroded bank/slope	☐ Sand	☐ Large Boulder	
Bank Height:	0.41	m	XXXXX	Bank stabilization	Bank Height:	0.35	m
Bank Angle:	15	°	-*-*-*-	Fence	Bank Angle:	10	°
Root Depth:	0.10	m	VVV	Grasses	Root Depth:	0.10	m
Root Density:	30	%		Leaning tree	Root Density:	15	%
Undercut:	0	m		Tree	Undercut:	0	m
Erosion Pin:	0.20	m	* * *	Woody Debris	Erosion Pin:	0.20	m
Torvane:	1.0	kg/cm²		Sediment sample	Torvane:	0.75	kg/cm²
Penetrometer:	0.5	kg/cm²		Erosion pin	Penetrometer:	0.5	kg/cm²
Foot Used:	☐ Yes ☑ No			Scour/bed chain	Foot Used:	☐ Yes ☑ No	

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Detailed Cross-Section Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS-5
Time:	3:19	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

					Notes
filename- PM25011					
	RTK PT500				

Cross-sectional Morphology (Table 22)

☐ Riffle ☐ Pool ☑ Run ☐ Other

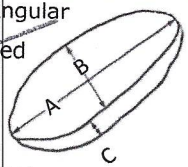
Substrate Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☒ None

Pebble Count Measurements A/B/C Axes (cm):

A	B	C	A	B	C	A	B	C	A	B	C
fines											
2			12			22			32		
3			13			23			33		
4	4	4	14	14	14	24	24	24	34	34	34
5			15			25			35		
6			16			26			36		
7			17			27			37		
8	8	8	18	18	18	28	28	28	38	38	38
9			19			29			39		
10			20			30			40		

Particle Shape: ☐ Platy ☐ Very Angular ☐ Sub-angular ☐ Angular ☐ Rounded ☐ Sub-Rounded ☐ Well Rounded



[Pebble ABC axis guide]

Embededness (%): _____

Subpavement: _____

Parent Material Bed Coverage (%) _____

Sorting (Table 20): ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Obsv ☒ Not Obsv ☐ Not Visible - Reason: _____

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active (%): _____

Velocity

☐ Measured _____ m/s Method: WB

☑ Estimated 0.04 m/s XS ID: XS5

Distance 1 m Time _____ s V _____ m/s

Distance 1 m Time _____ s V _____ m/s

Distance 1 m Time _____ s V _____ m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

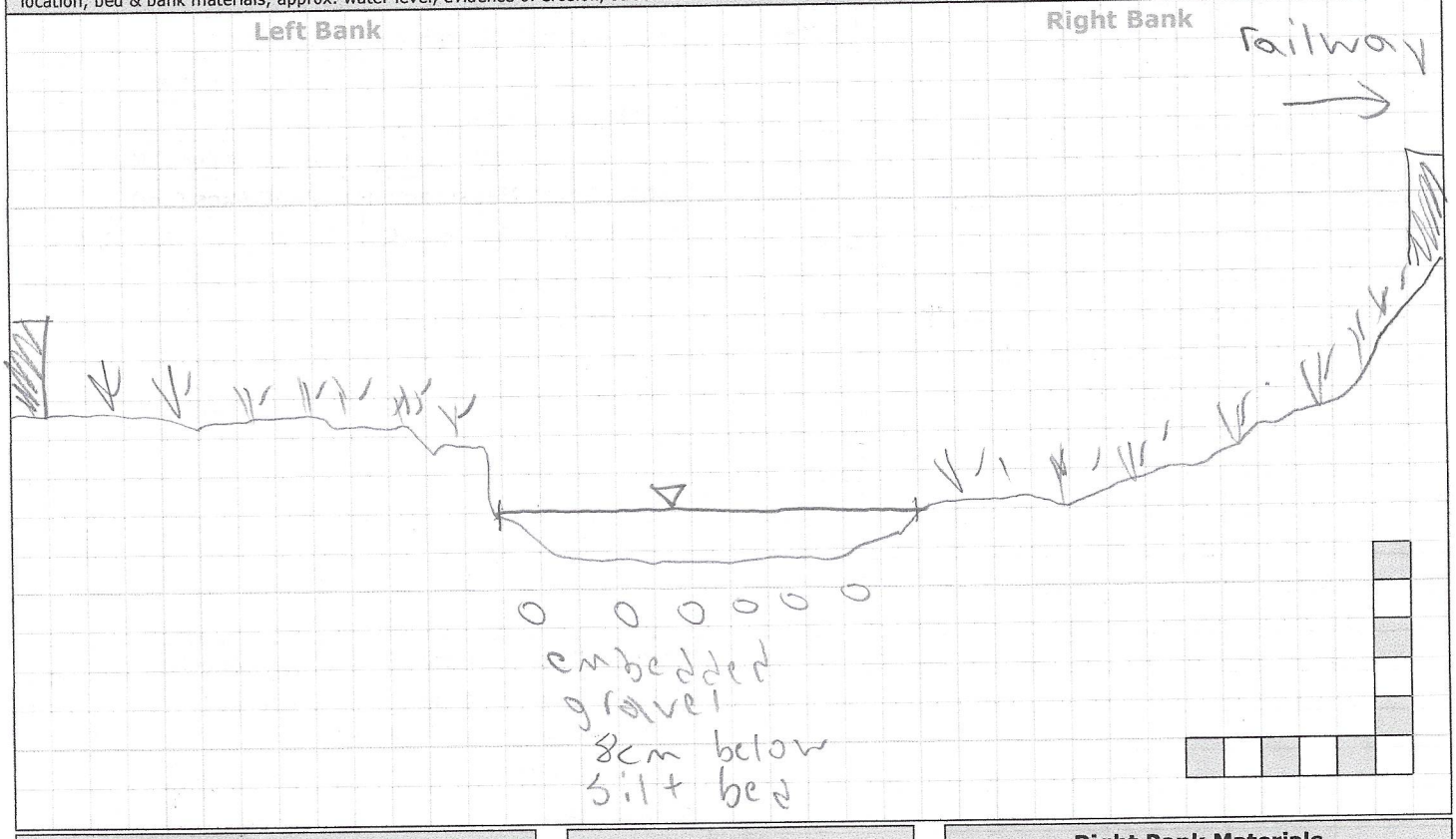
GEO MORPHIX™

Bank Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS5
Time:	3:19	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond, ON
Field Staff:	HM KC	**Watershed/Subwatershed:**	Jock River

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock	☐ Gravel	
☐ Till	☐ Small Cobble	
☐ Clay	☐ Large Cobble	
☒ Silt	☐ Small Boulder	
☐ Sand	☐ Large Boulder	
Bank Height:	0.5	m
Bank Angle:	25	°
Root Depth:	0.08	m
Root Density:	15	%
Undercut:	0.07	m
Erosion Pin:	/	m
Torvane:	0.25	kg/cm²
Penetrometer:	0.5	kg/cm²
Foot Used:	☐ Yes ☒ No	

Features

	Station location
	Monumented XS
	Monumented photo
------	Undercut bank
#####	Eroded bank/slope
	Bank stabilization
x-x-x	Fence
	Grasses
	Leaning tree
	Tree
	Woody Debris
	Sediment sample
	Erosion pin
	Scour/bed chain

Right Bank Materials

☐ Bedrock	☒ Gravel	
☐ Till	☐ Small Cobble	
☐ Clay	☐ Large Cobble	
☒ Silt	☐ Small Boulder	
☐ Sand	☐ Large Boulder	
Bank Height:	0.9	m
Bank Angle:	10	°
Root Depth:	0.03	m
Root Density:	10	%
Undercut:	0	m
Erosion Pin:	/	m
Torvane:	0.25	kg/cm²
Penetrometer:	0.25	kg/cm²
Foot Used:	☐ Yes ☒ No	

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Detailed Cross-Section Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS6
Time:	3:35	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

					Notes
	RTK XS 6				
	PT 600				

Cross-sectional Morphology (Table 22)

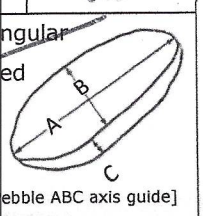
☐ Riffle ☐ Pool ☒ Run ☐ Other

Substrate Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☒ None

Pebble Count Measurements A/B/C Axes (cm):

A	B	C	A	B	C	A	B	C	A	B	C
Fines											



[Pebble ABC axis guide]

Particle Shape: ☐ Platy ☐ Very Angular ☐ Sub-angular ☐ Angular ☐ Rounded ☐ Sub-Rounded ☐ Well Rounded

Embededness (%): _____

Subpavement: _____

Parent Material Bed Coverage (%) _____

Sorting (Table 20): ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Obsv ☒ Not Obsv ☐ Not Visible - Reason: _____

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active (%): _____

Velocity

☐ Measured _____ m/s Method: _____

☐ Estimated _____ m/s XS ID: _____

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

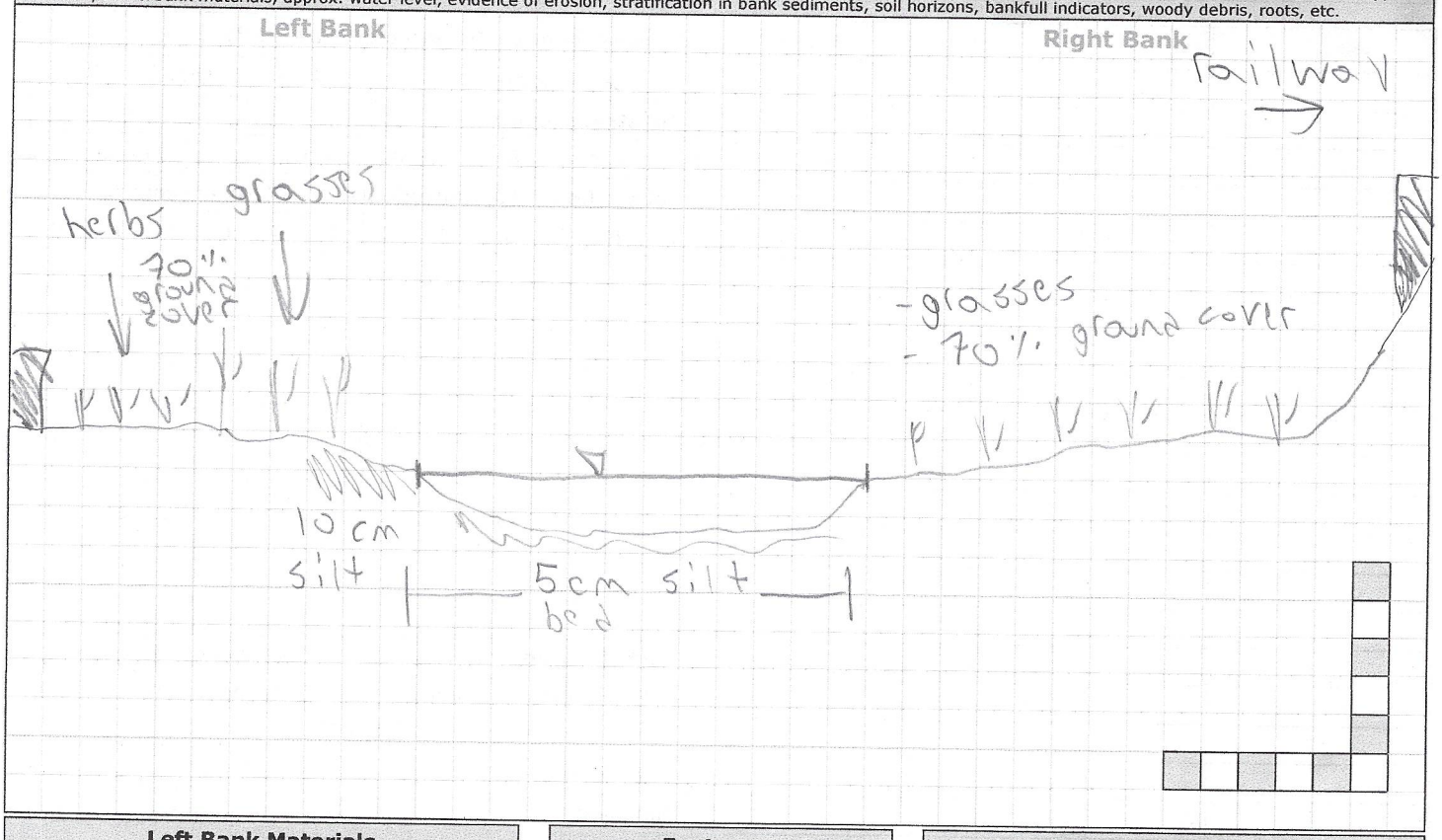
GEO MORPHIX

Bank Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS6
Time:	3:35	**Reach:**	MC3
Weather:	28°C sunny	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Jock River

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☐ Clay	☐ Large Cobble		
☒ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	0.65	m	
Bank Angle:	20	°	
Root Depth:	0.10	m	
Root Density:	15	%	
Undercut:	0	m	
Erosion Pin:	/	m	
Torvane:	0.25	kg/cm²	
Penetrometer:	0.5	kg/cm²	
Foot Used:	☐ Yes ☒ No		

Features

	Station location
	Monumented XS
	Monumented photo
------	Undercut bank
/////	Eroded bank/slope
XXXXX	Bank stabilization
x-x-x	Fence
	Grasses
	Leaning tree
	Tree
	Woody Debris
	Sediment sample
	Erosion pin
	Scour/bed chain

Right Bank Materials

☐ Bedrock	☒ Gravel		
☐ Till	☐ Small Cobble		
☐ Clay	☐ Large Cobble		
☒ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	1.25	m	
Bank Angle:	15	°	
Root Depth:	0.08	m	
Root Density:	15	%	
Undercut:	0	m	
Erosion Pin:	/	m	
Torvane:	0	kg/cm²	
Penetrometer:	0.5	kg/cm²	
Foot Used:	☐ Yes ☒ No		

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

GEO MORPHIX™

Detailed Cross-Section Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS7
Time:	3:47	**Reach:**	MC3
Weather:	sunny 28°C	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Dock River

					Notes
	RTK PT 200				

Cross-sectional Morphology (Table 22)

☐ Riffle ☐ Pool ☒ Run ☐ Other

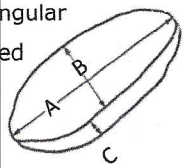
Substrate Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☑ None

Pebble Count Measurements A/B/C Axes (cm):

A	B	C	A	B	C	A	B	C	A	B	C
fines											

Particle Shape: ☐ Platy ☐ Very Angular ☐ Sub-angular ☐ Angular ☐ Rounded ☐ Sub-Rounded ☐ Well Rounded



[Pebble ABC axis guide]

Embededness (%): _____

Subpavement: _____

Parent Material Bed Coverage (%) 100

Sorting (Table 20): ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Obsv ☒ Not Obsv ☐ Not Visible - Reason: _____

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active (%): _____

Velocity

☐ Measured _____ m/s Method: _____

☐ Estimated _____ m/s XS ID: _____

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

Version #4
Last edited: 2025-03-04

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

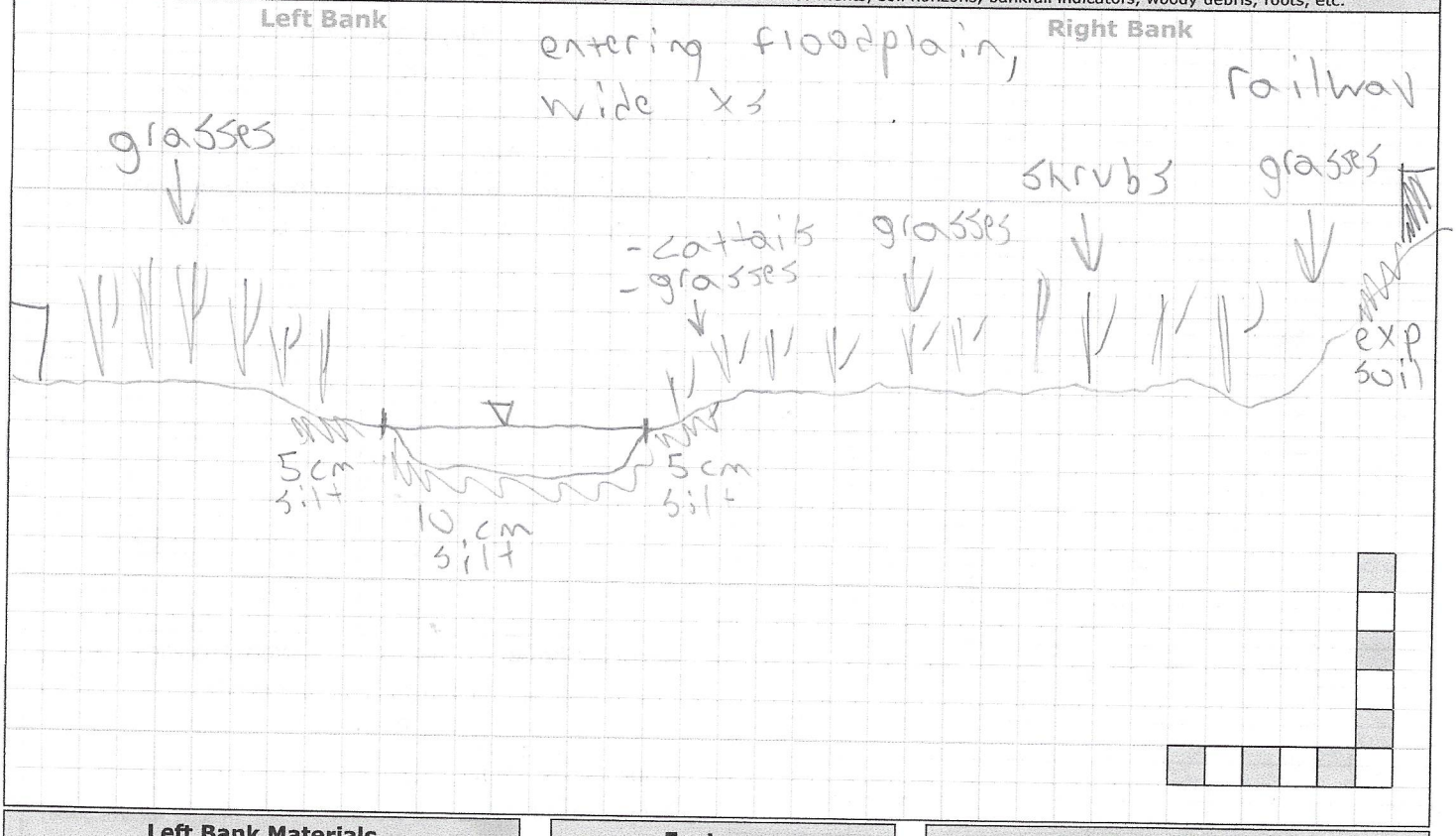
GEO MORPHIX

Bank Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS7
Time:	3:47	**Reach:**	MC3
Weather:	28°C sunny	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Dock River

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☐ Clay	☐ Large Cobble		
☒ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	0.5	m	
Bank Angle:	10	°	
Root Depth:	0.05	m	
Root Density:	5	%	
Undercut:	0	m	
Erosion Pin:	1	m	
Torvane:	0	kg/cm²	
Penetrometer:	0.25	kg/cm²	
Foot Used:	☐ Yes ☒ No		

Features

	Station location
	Monumented XS
	Monumented photo
------	Undercut bank
//////	Eroded bank/slope
XXXXX	Bank stabilization
--*	Fence
	Grasses
	Leaning tree
	Tree
* * *	Woody Debris
	Sediment sample
	Erosion pin
	Scour/bed chain

Right Bank Materials

☐ Bedrock	☐ Gravel		
☐ Till	☐ Small Cobble		
☐ Clay	☐ Large Cobble		
☒ Silt	☐ Small Boulder		
☐ Sand	☐ Large Boulder		
Bank Height:	1.4	m	
Bank Angle:	20	°	
Root Depth:	0.07	m	
Root Density:	10	%	
Undercut:	0	m	
Erosion Pin:		m	
Torvane:	0.25	kg/cm²	
Penetrometer:	0.25	kg/cm²	
Foot Used:	☐ Yes ☒ No		

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KC

GEO MORPHIX™

Detailed Cross-Section Characteristics Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS 8
Time:	16:06	**Reach:**	MC3
Weather:	Sunny 28°C	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	dock River

					Notes
KTK-	PN25011				
	Pt starts @	800			

Cross-sectional Morphology (Table 22)

☐ Riffle ☐ Pool ☒ Run ☐ Other

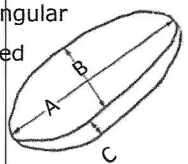
Substrate Sample:

☐ Bed ☐ Bank ☐ Subpavement ☐ Water ☒ None

Pebble Count Measurements A/B/C Axes (cm):

A	B	C	A	B	C	A	B	C	A	B	C
fines											

Particle Shape: ☐ Platy ☐ Very Angular ☐ Sub-angular ☐ Angular ☐ Rounded ☐ Sub-Rounded ☐ Well Rounded



[Pebble ABC axis guide]

Embededness (%): _____

Subpavement: _____

Parent Material Bed Coverage (%) 100

Sorting (Table 20): ☐ Well ☐ Moderate ☐ Poor ☐ Very poor

Sediment Transport

☐ Obsv ☒ Not Obsv ☐ Not Visible - Reason: _____

If Observed (Table 21):

☐ Suspended ☐ Sliding ☐ Rolling ☐ Saltation

Percentage of Bed Active (%): _____

Velocity

☐ Measured _____ m/s Method: _____

☐ Estimated _____ m/s XS ID: _____

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Distance _____ m Time _____ s V _____ m/s

Discharge

☐ Estimated _____ m^3/s Method: _____

☐ Measured _____ m^3/s XS ID: _____

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Depth _____ m Width _____ m V_{60} _____ m/s

Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

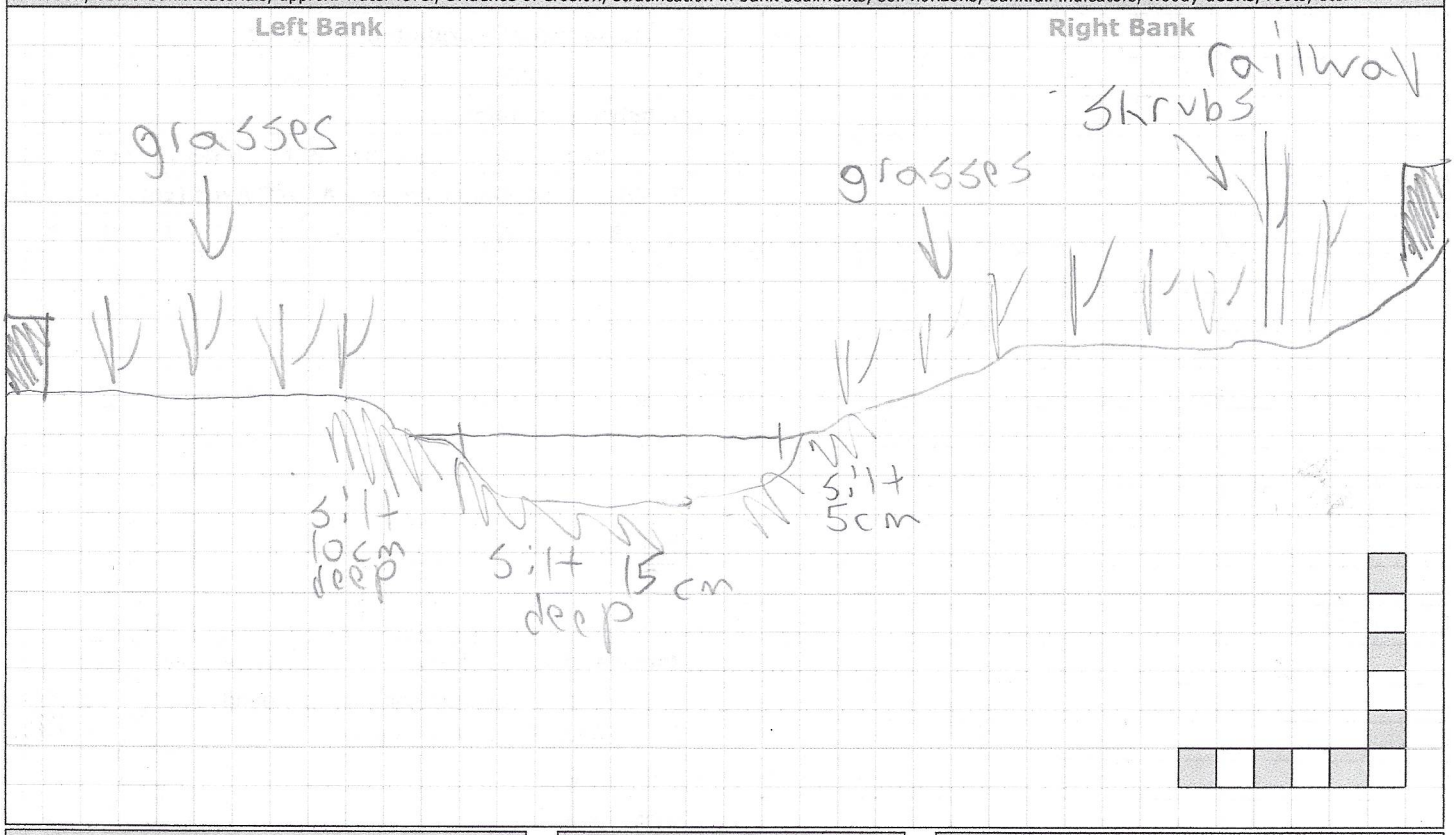
GEO MORPHIX

Bank Characteristics

Project Number: 25011

Date:	2025-07-09	**Cross-section:**	XS8
Time:	16:06	**Reach:**	MC3
Weather:	Sunny 28°C	**Location:**	Richmond, ON
Field Staff:	KC HM	**Watershed/Subwatershed:**	Dock River

Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc.



Left Bank Materials			Features		Right Bank Materials		
☐ Bedrock	☐ Gravel			Station location	☐ Bedrock	☐ Gravel	
☐ Till	☐ Small Cobble			Monumented XS	☐ Till	☐ Small Cobble	
☐ Clay	☐ Large Cobble			Monumented photo	☐ Clay	☐ Large Cobble	
☒ Silt	☐ Small Boulder			Undercut bank	☒ Silt	☐ Small Boulder	
☐ Sand	☐ Large Boulder			Eroded bank/slope	☐ Sand	☐ Large Boulder	
Bank Height:	0.5	m		Bank stabilization	Bank Height:	1.5	m
Bank Angle:	10	°		Fence	Bank Angle:	15	°
Root Depth:	0.05	m		Grasses	Root Depth:	0.09	m
Root Density:	5	%		Leaning tree	Root Density:	10	%
Undercut:	0	m		Tree	Undercut:	0	m
Erosion Pin:	/	m		Woody Debris	Erosion Pin:	/	m
Torvane:	0	kg/cm²		Sediment sample	Torvane:	0.25	kg/cm²
Penetrometer:	0.25	kg/cm²		Erosion pin	Penetrometer:	0.25	kg/cm²
Foot Used:	☐ Yes ☒ No			Scour/bed chain	Foot Used:	☐ Yes ☒ No	

Additional Notes

Photos:

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: HM

Appendix D:
Detailed Assessment Data Summaries

Detailed Geomorphological Assessment Summary

Marlborough Creek, Reach MC3

Project Number:	PN25011	**Date:**	2025-07-09
Client:	Tamarack Homes / Taggart Group	**Length Surveyed (m):**	313.7
Location:	Richmond, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	5.665	**Dominant Riparian Vegetation Type:**	Trees and srhubs
Geology/Soils:	**Fine textured glaciomarine deposits**	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forested	**Width of Riparian Cover:**	1-4 right bank, >10 left bar
Valley Type:	**Partially Confined**	**Age Class of Riparian Vegetation:**	Established
Dominant Instream Vegetation Type:	Floating/ Rooted Emergent	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	85%	**Density of Woody Debris:**	Moderate

Hydrology

Estimated Discharge (m^3/s):	0.00	**Estimated Bankfull Discharge (m^3/s):**	0.66
Modelled 2-year Discharge (m^3/s):	N/A	**Estimated Bankfull Velocity (m/s):**	0.73
Modelled 2-year Velocity (m/s):	N/A		

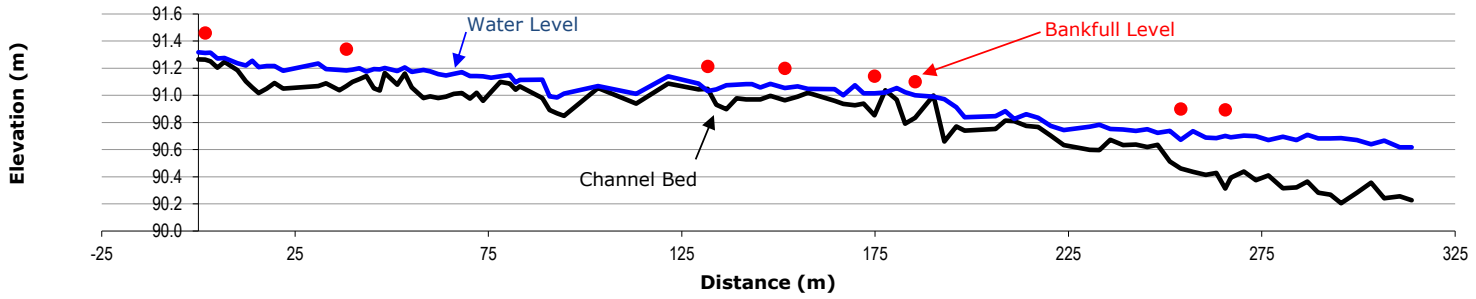
Profile Characteristics

Bankfull Gradient (%):	0.49
Channel Bed Gradient (%):	0.28
Riffle Gradient (%):	No riffle/pools
Riffle Length (m):	No riffle/pools
Riffle-Pool Spacing (m):	No riffle/pools

Planform Characteristics

Sinuosity:	1.14
Meander Belt Width (m):	See Report
Radius of Curvature (m):	Straightened Channel
Meander Amplitude (m):	Straightened Channel
Meander Wavelength (m):	Straightened Channel

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.35	2.00	0.80
Bank Angle (deg):	1	35	17
Root Depth (m):	0.03	0.20	0.10
Root Density (%):	5	30	15
Bank Undercut (m):	0.00	0.07	0.00

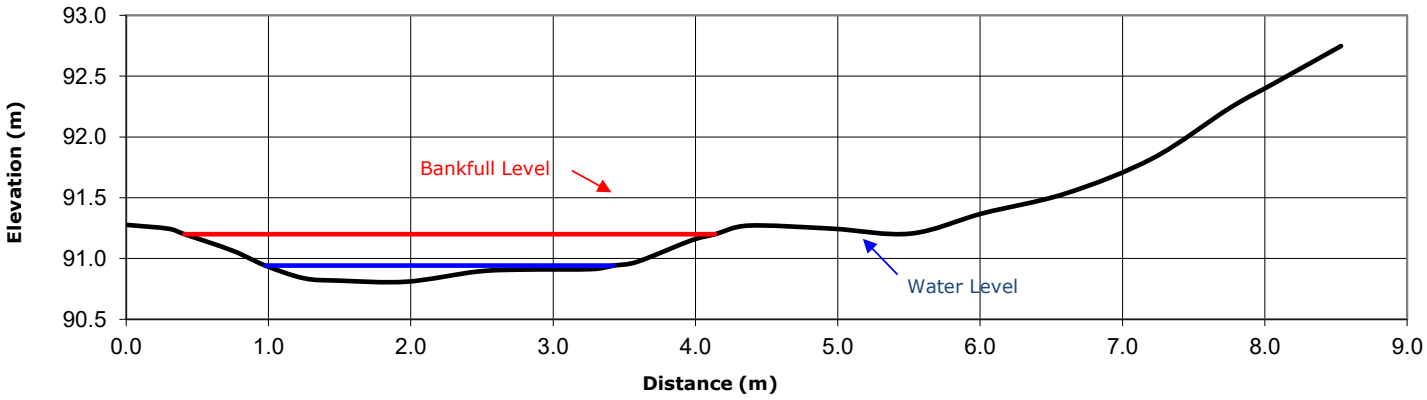
	Minimum	Maximum	Average
Penetrometer Value (kg/cm3):	0	1.25	0.4
Bank Material (range):		Clay/Silt to Gravel	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	3.01	6.85	4.13
Average Bankfull Depth (m):	0.06	0.25	0.22
Bankfull Width/Depth (m/m):	16	65	28
Wetted Width (m):	0.30	3.14	2.22
Average Water Depth (m):	0.01	0.20	0.08
Wetted Width/Depth (m/m):	15	126	46
Entrenchment Ratio (m/m):	>2.2 (Slight/Low Entrenchment)		
Maximum Water Depth (m):	0.02	0.35	0.14
Manning's *n*:		0.040	

Photograph at cross section 4 (looking upstream)

Representative Cross-Section 4



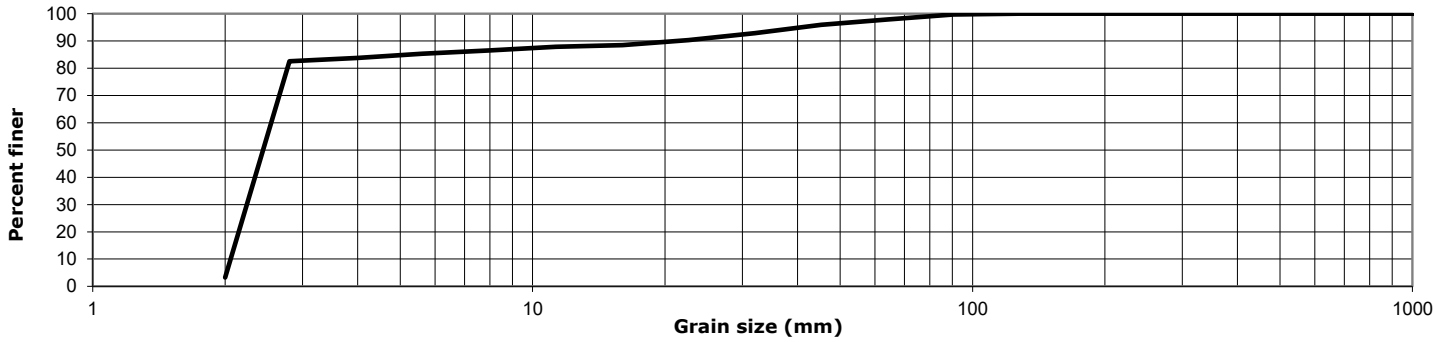
Substrate Characteristics

Particle Size (mm)

D_{10} :	0.2
D_{50} :	0.98
D_{84} :	4.25

Subpavement:	Glaciolacustrine deposits
Particle Shape:	N/A
Embeddedness (%):	N/A
Particle Range (riffle):	N/A
Particle Range (pool):	N/A

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	10.56
for D_{50}:	0.20	**Tractive Force at 2-year flow (N/m^2):**	N/A
for D_{84}:	0.38	**Critical Shear Stress (D_{50}) (N/m^2):**	0.71
Unit Stream Power at Bankfull (W/m^2):	8		

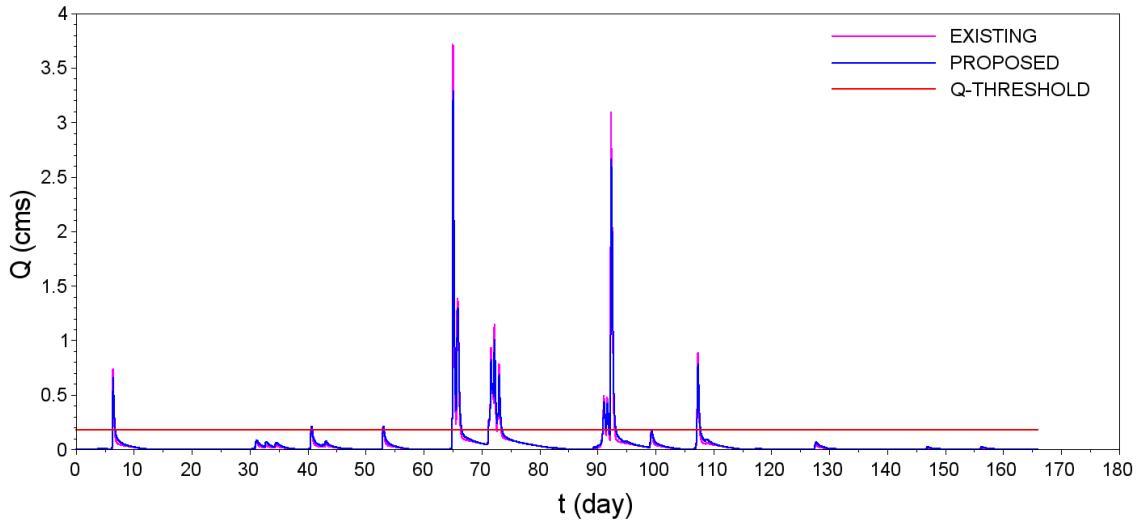
General Field Observations

Channel Description

The subject reach of Marlborough creek in Richmond, MC3, was characterized by a sinuous channel set within a partially confined, wooded valley. The dominant riparian vegetation consisted of established trees and shrubs which provided some cover over the channel. Channel bed morphology consisted of a lack of riffle-pool sequences and was relatively planar. The channel exhbited evidence of systemic aggradation as sedminent depths gradually increased in the downstream extents of the channel. Riparian vegetation along the right bank was limited to 1-4 channel widths due to the railway which acted as the right bank valley wall, while the left bank riparian vegetation extened over 10 channel widths past the bank which consisted of established forest.

Cross Section 2 - Facing Uptream

Appendix E:
Erosion Exceedance Hydrographs



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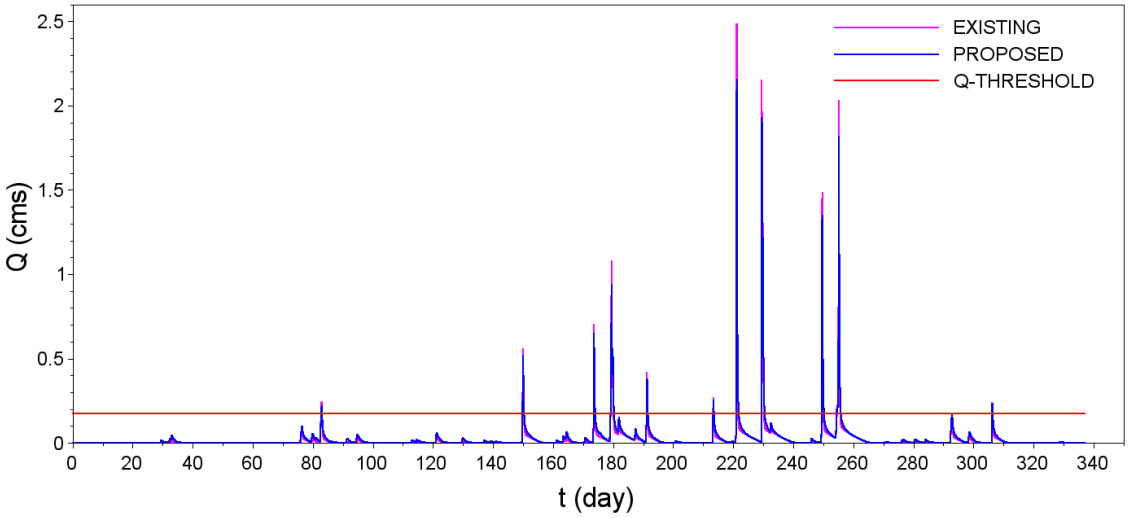

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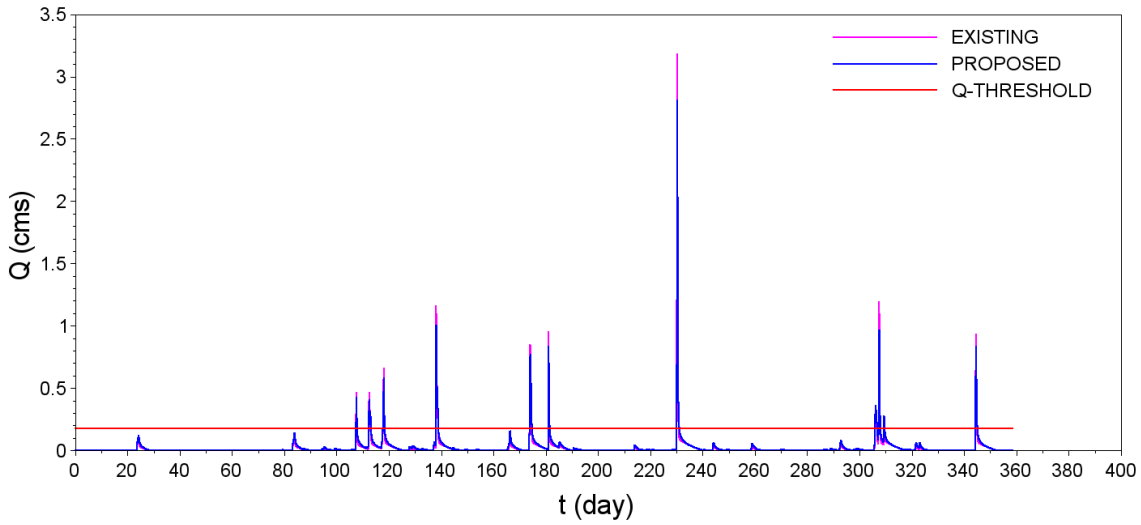

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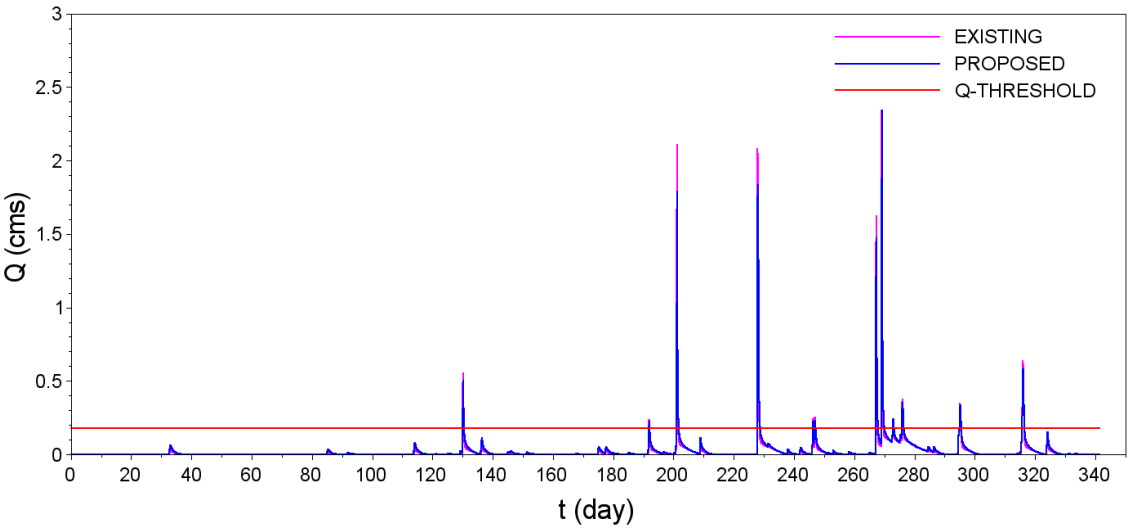

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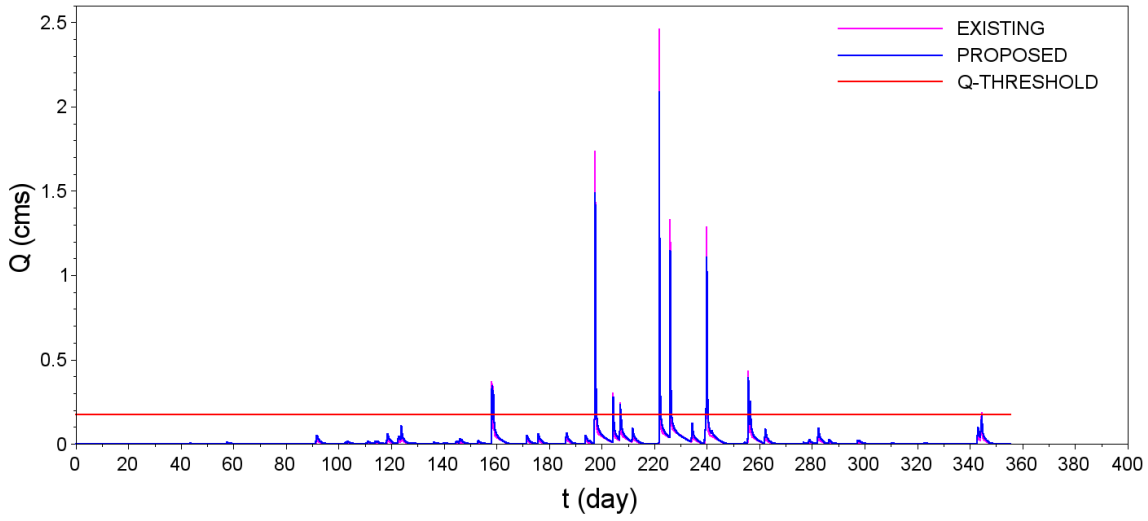

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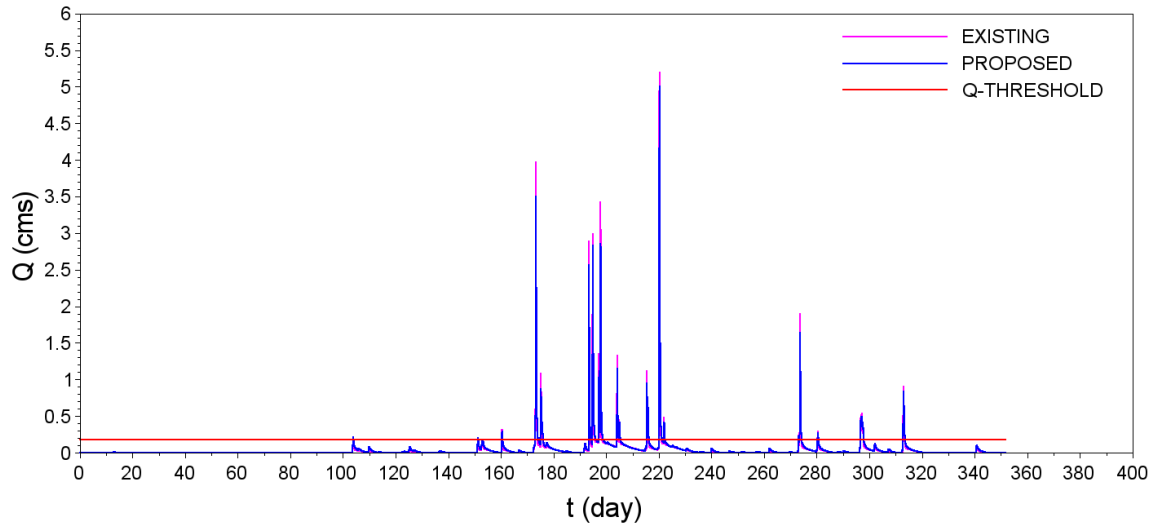

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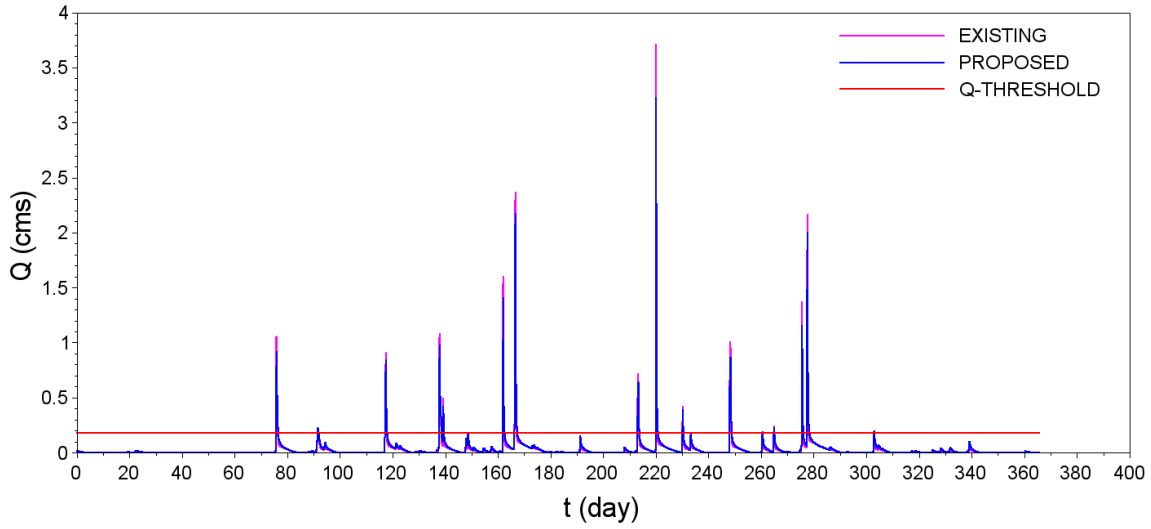

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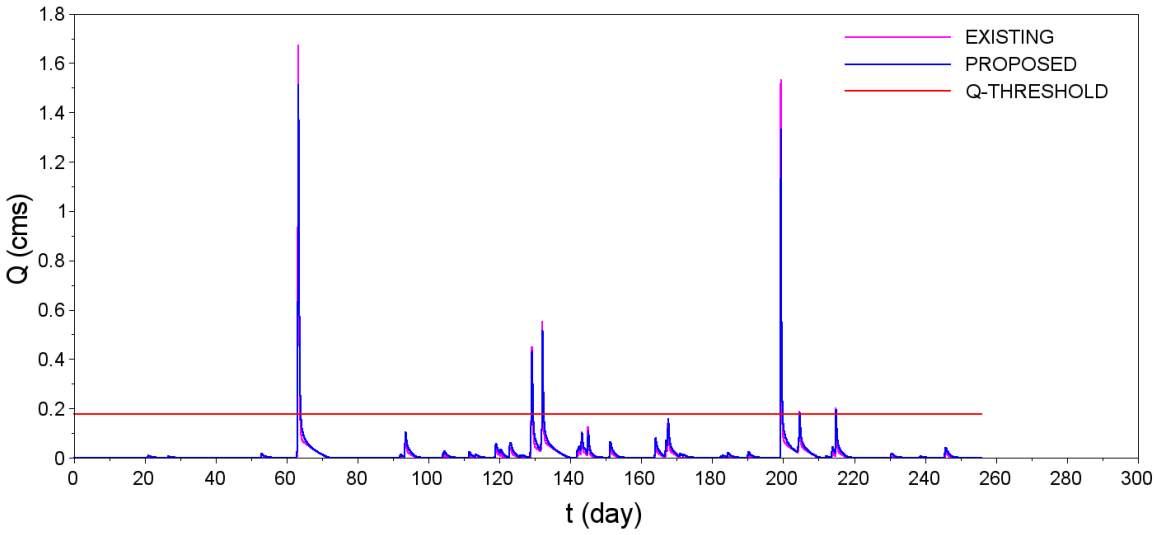

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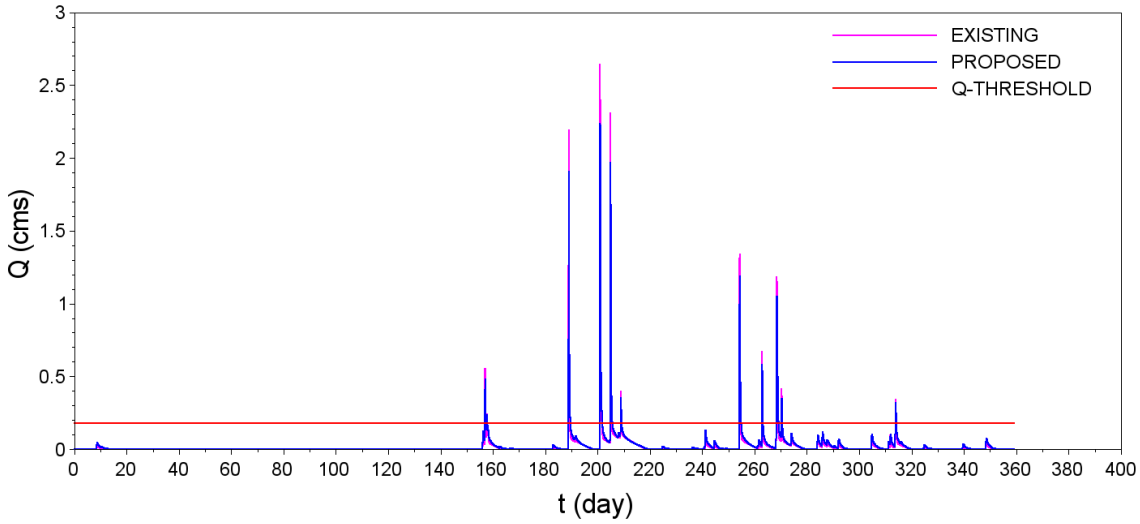

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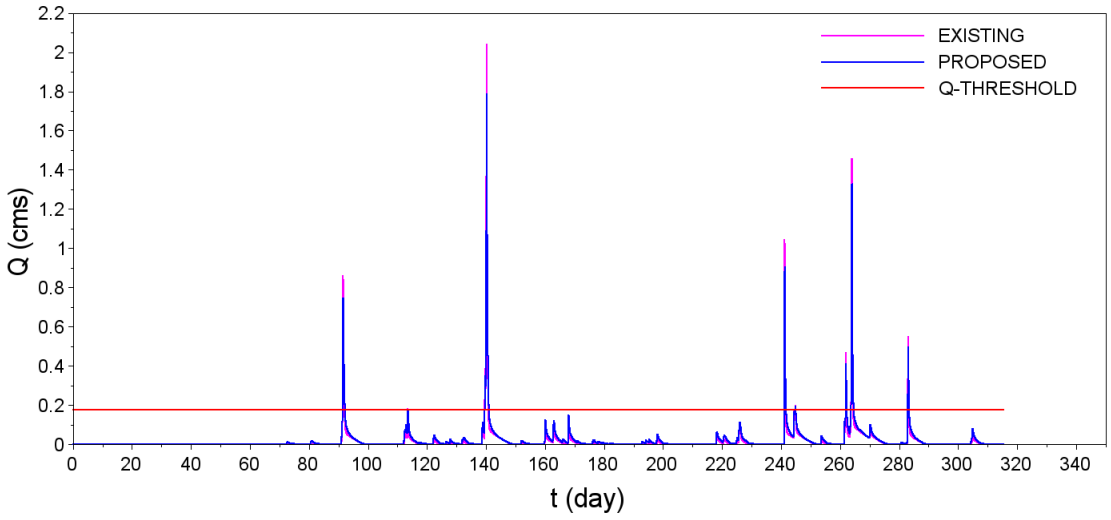

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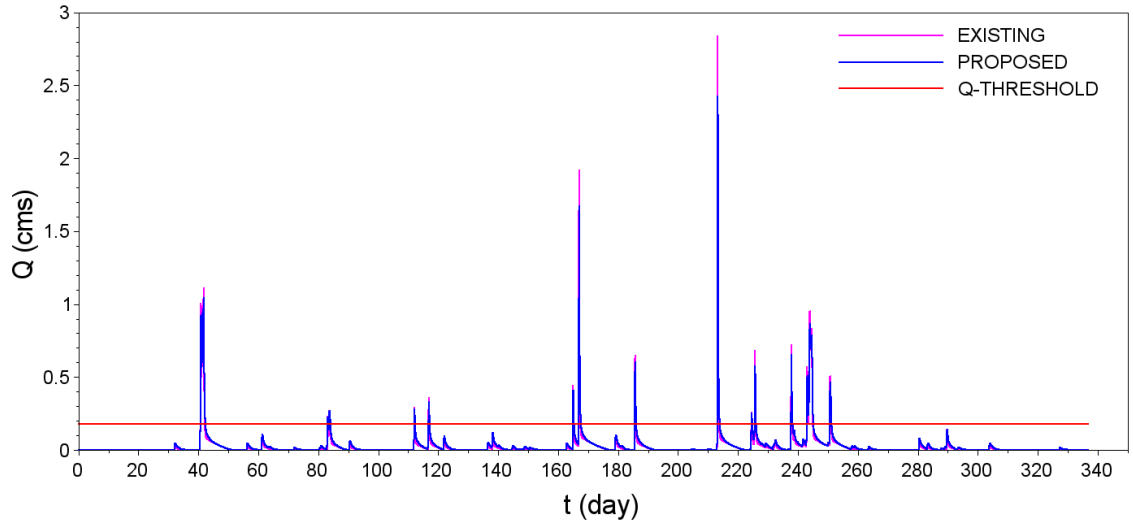

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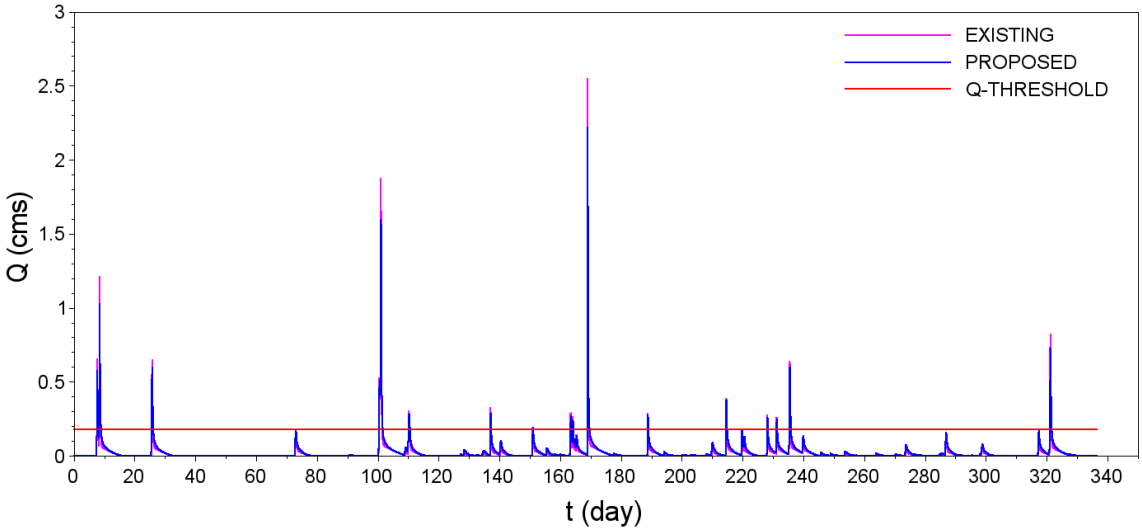

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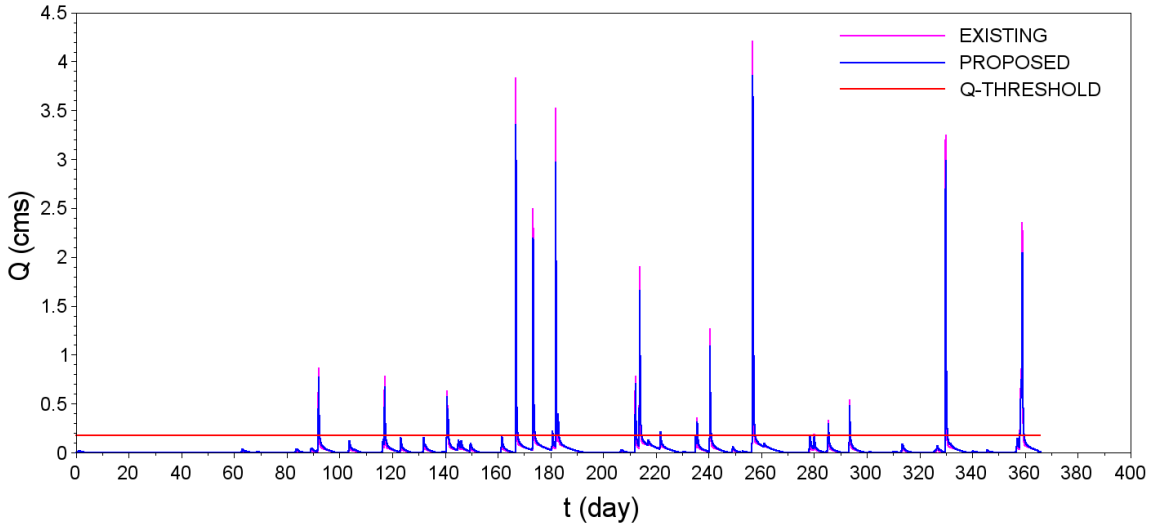

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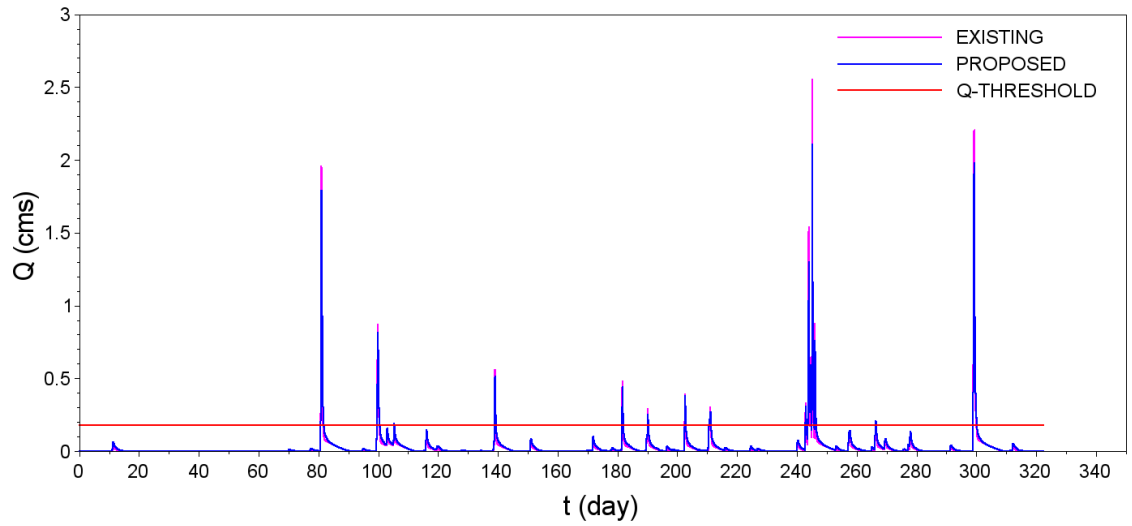

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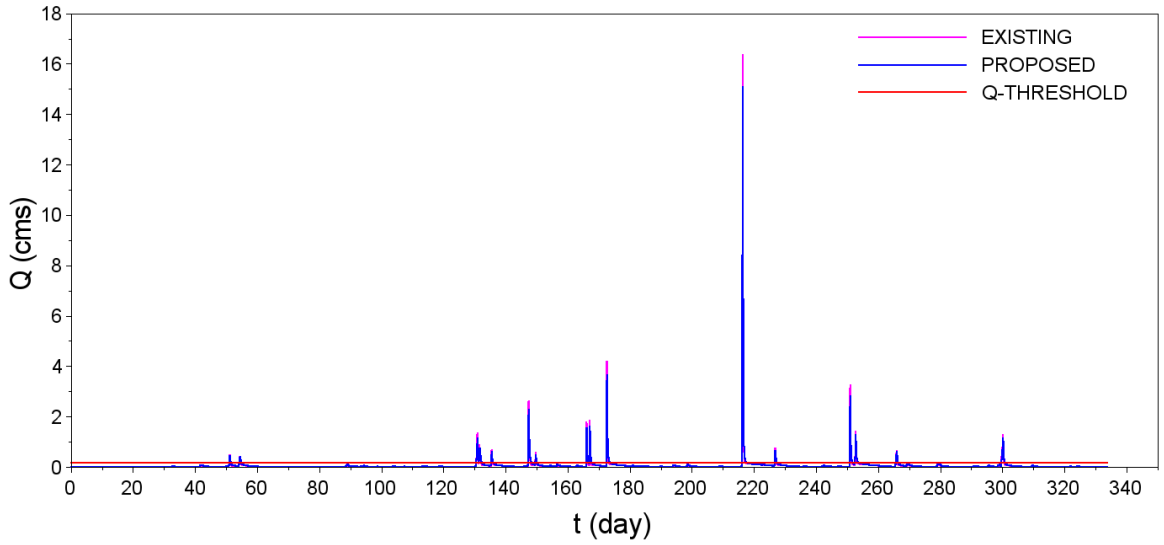

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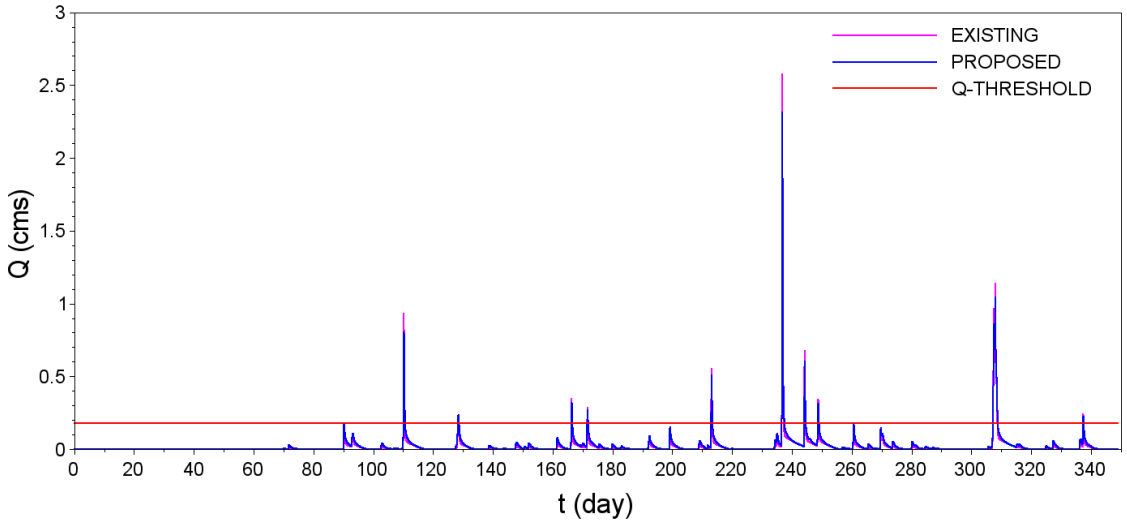

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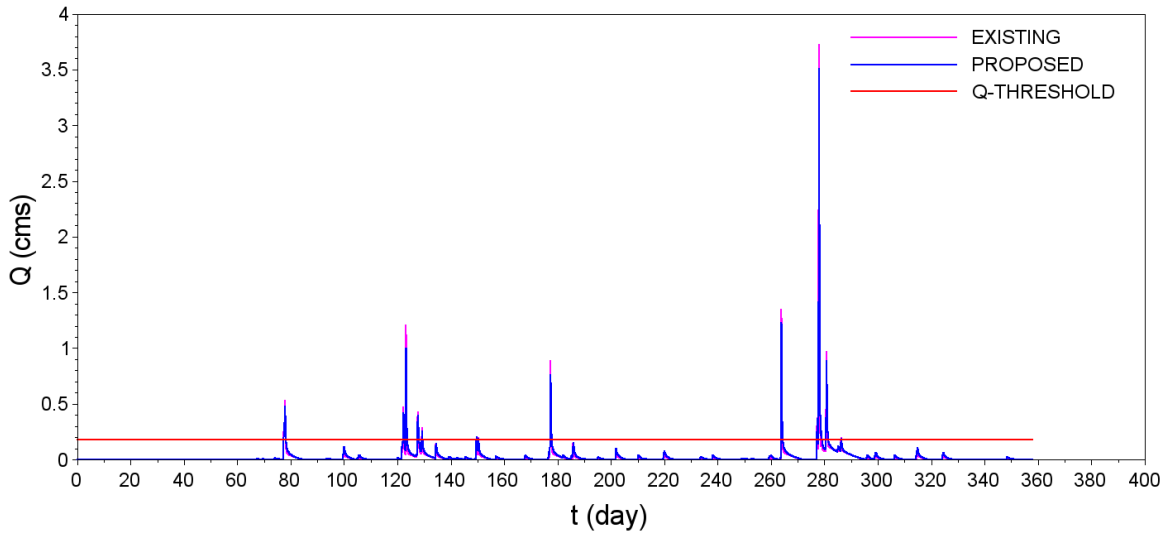

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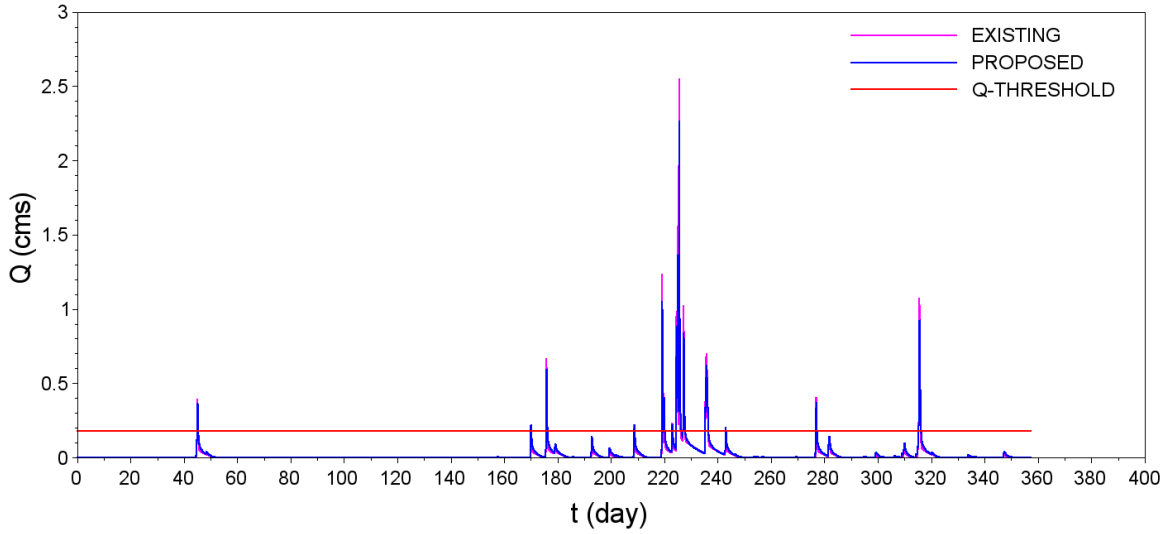

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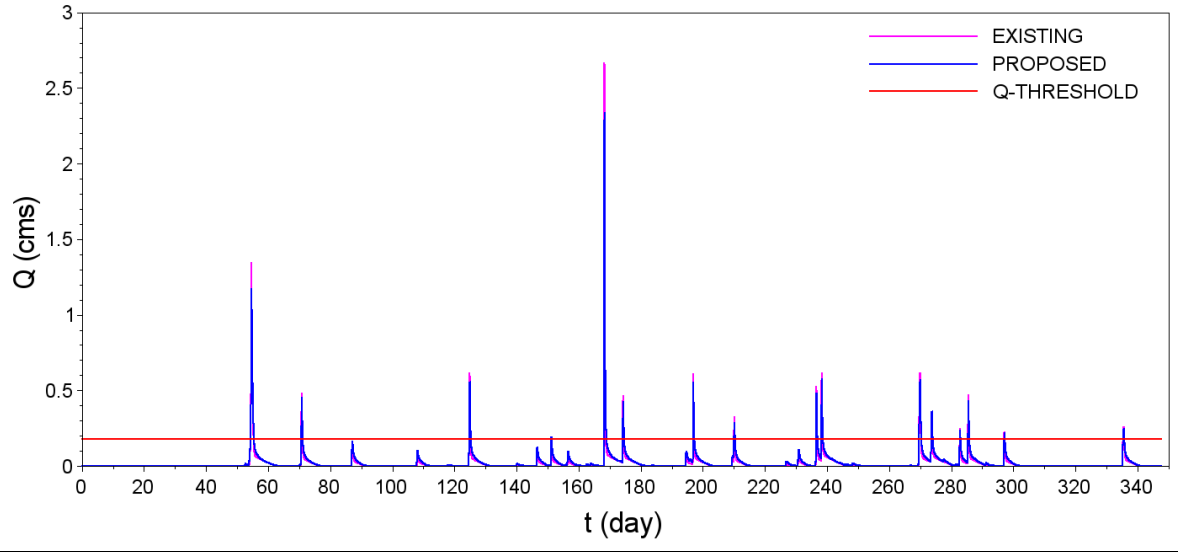

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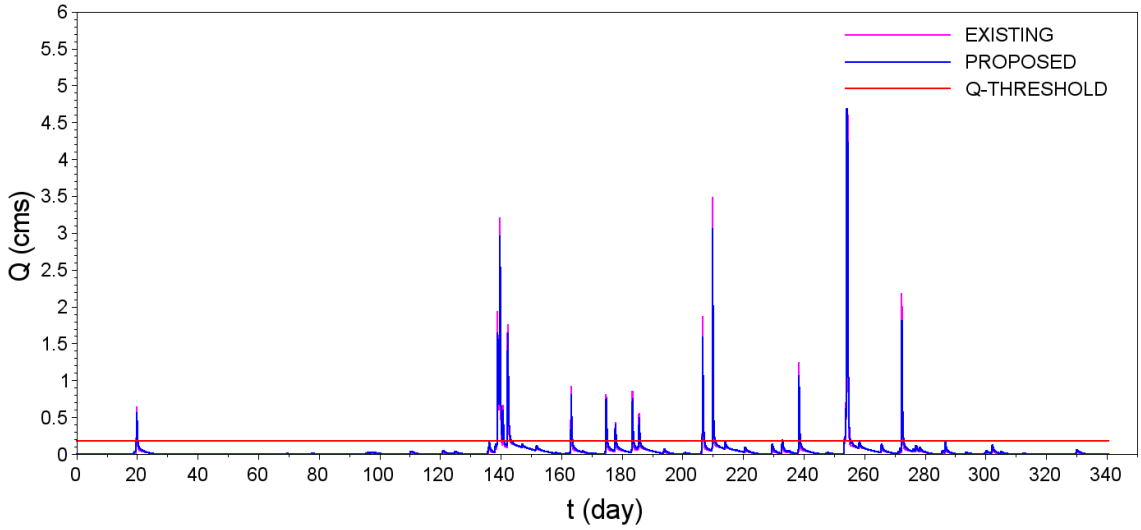

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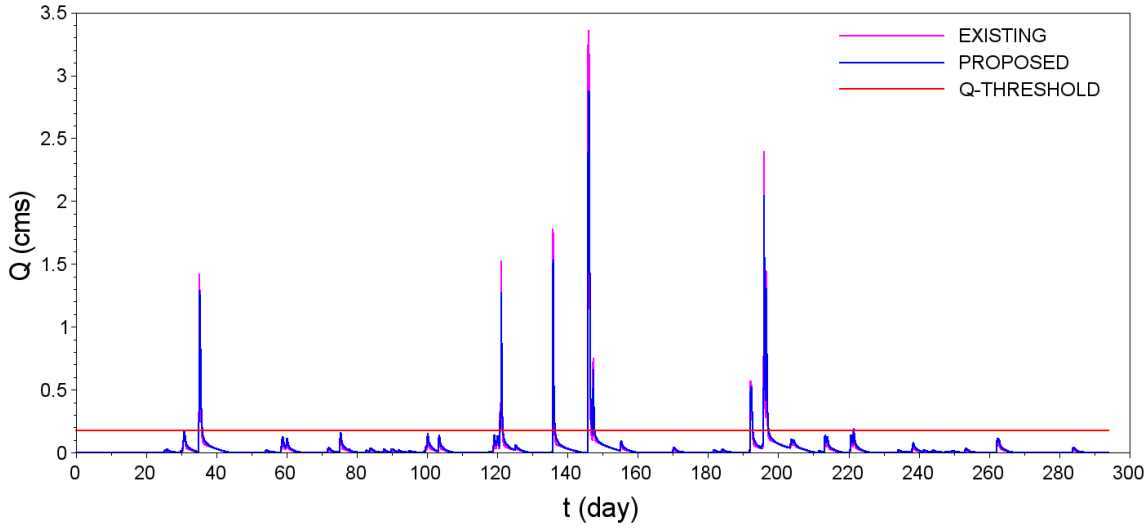

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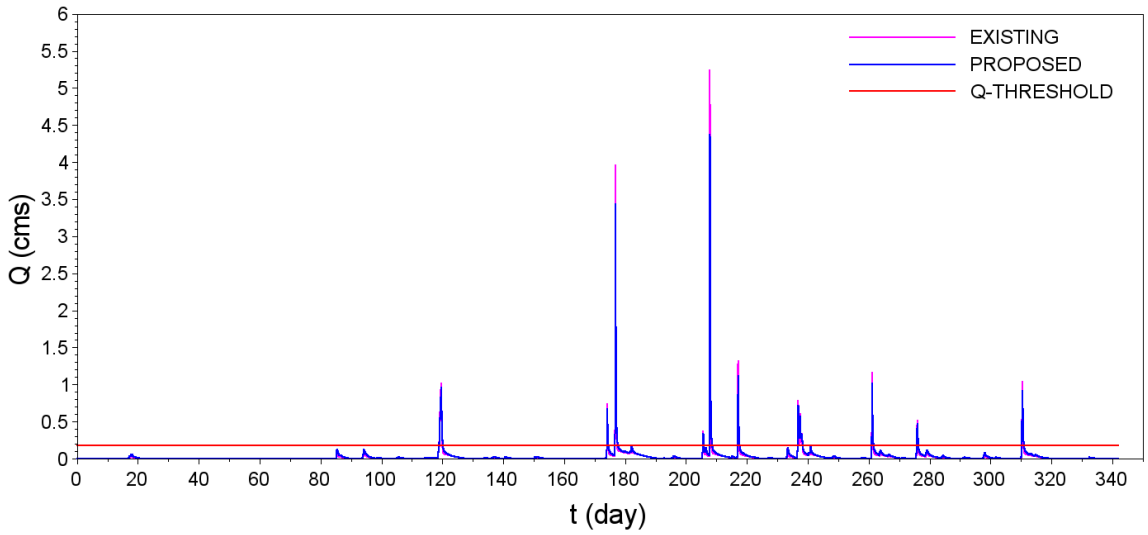

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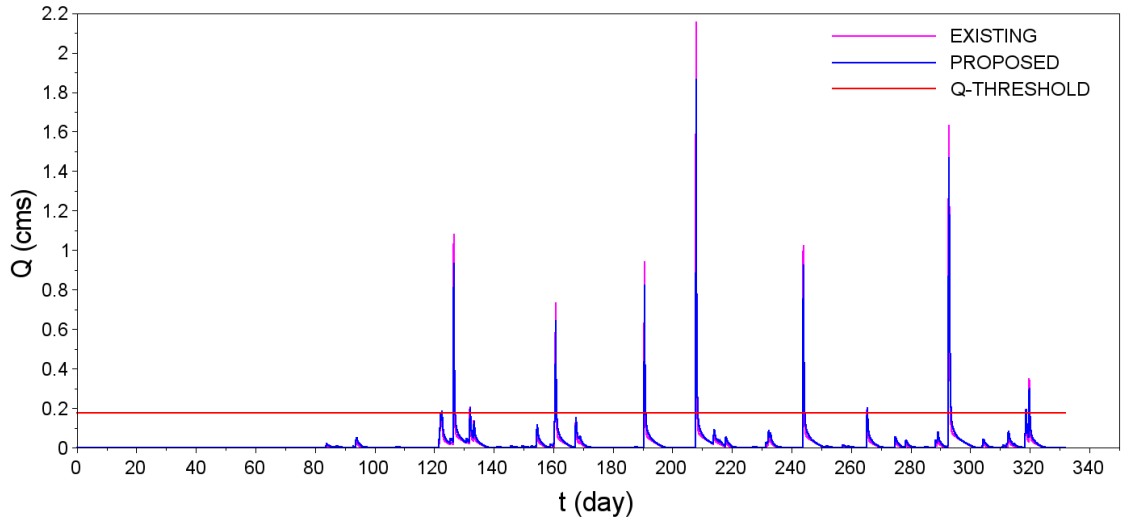

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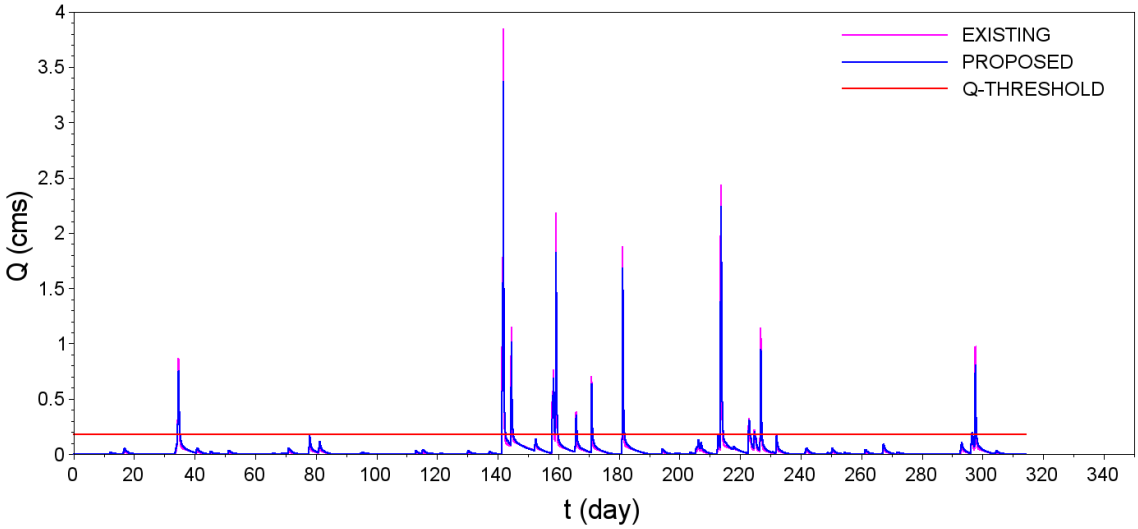

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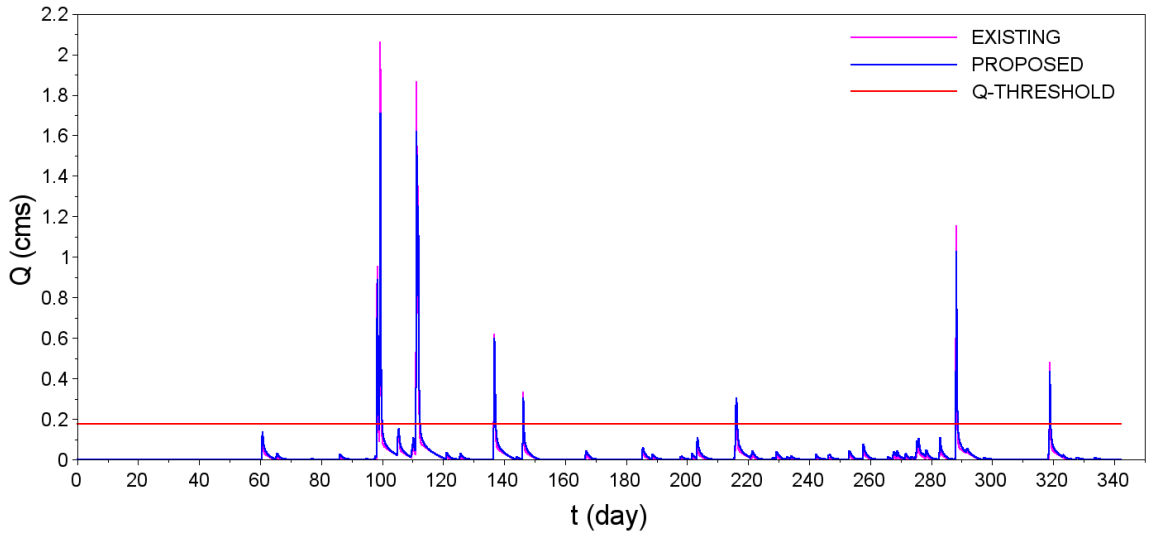

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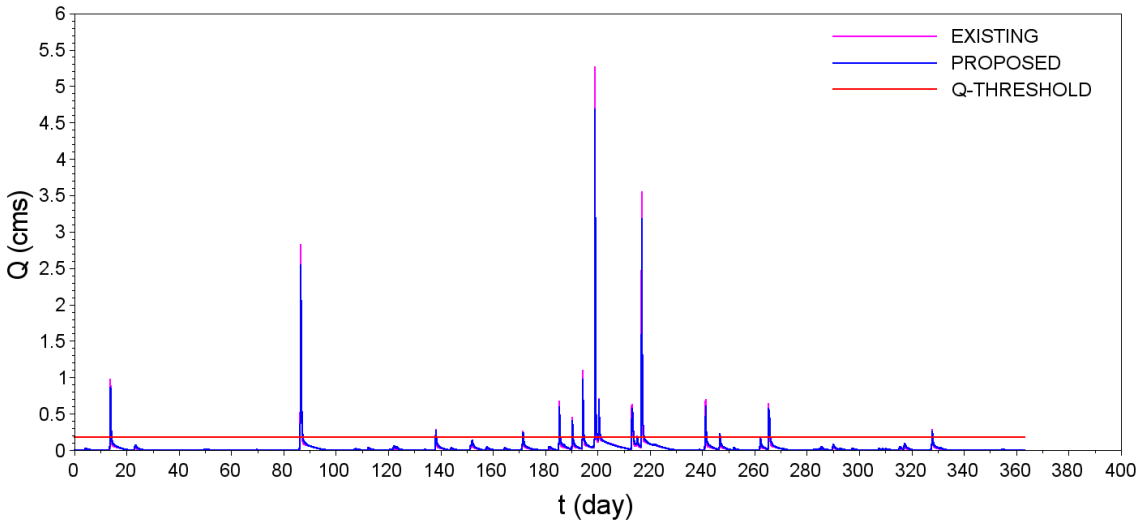

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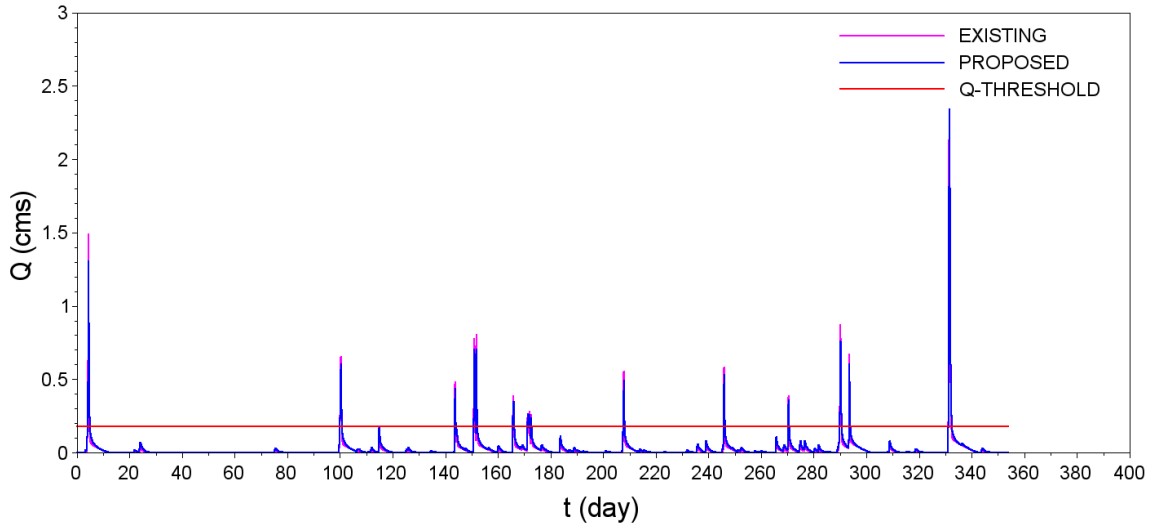

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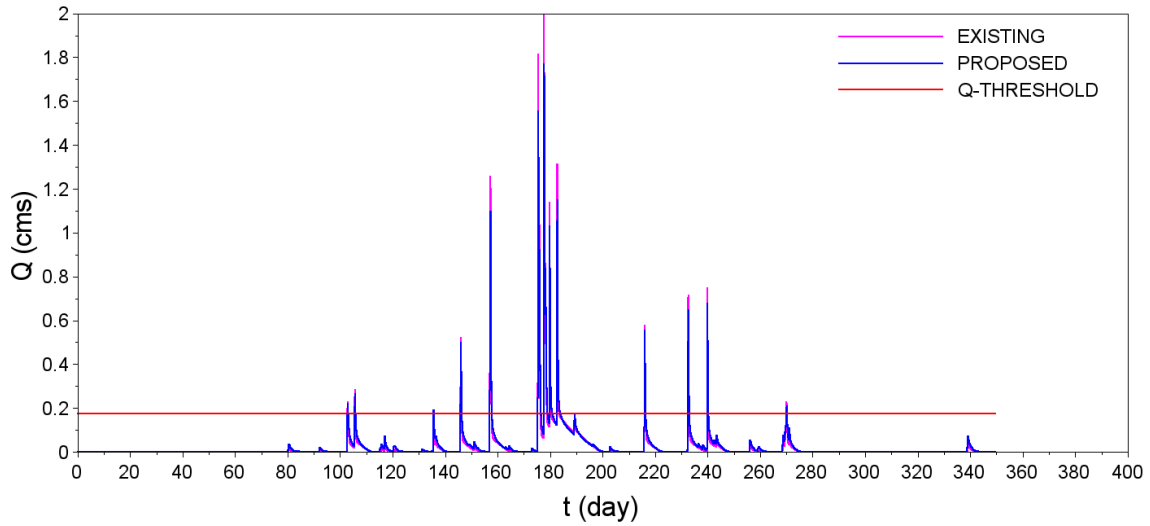

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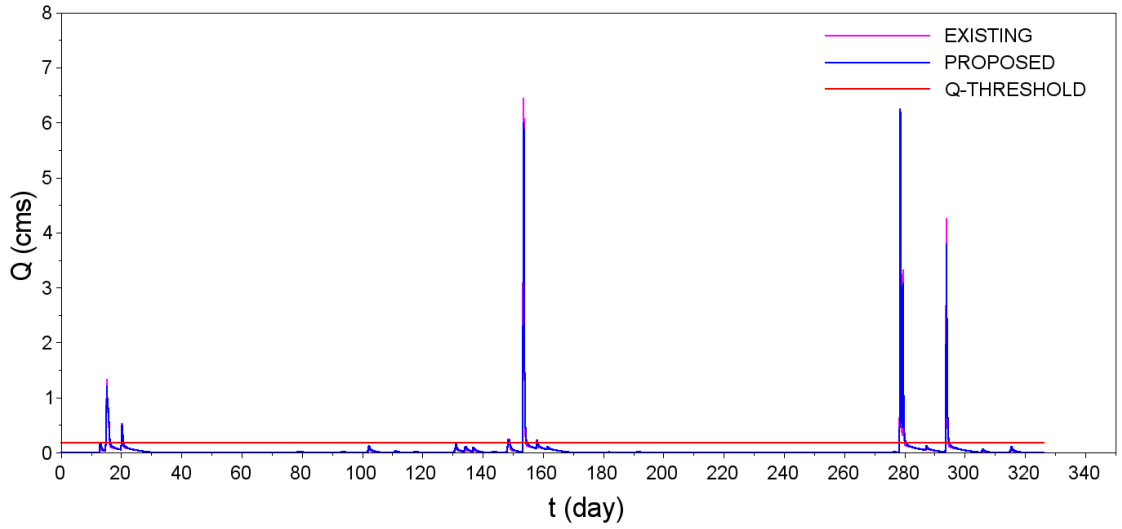

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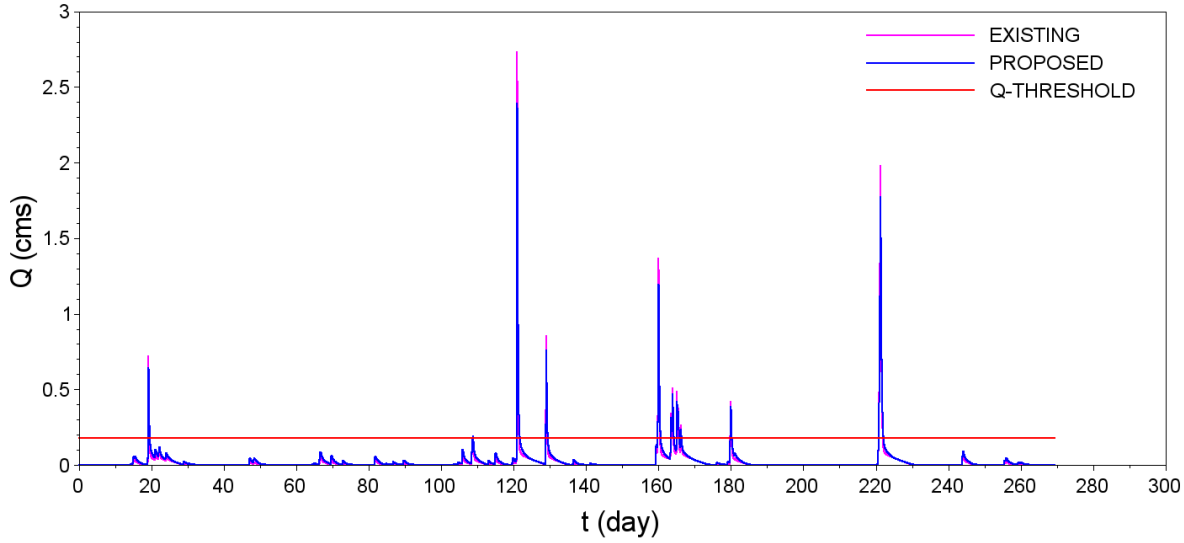

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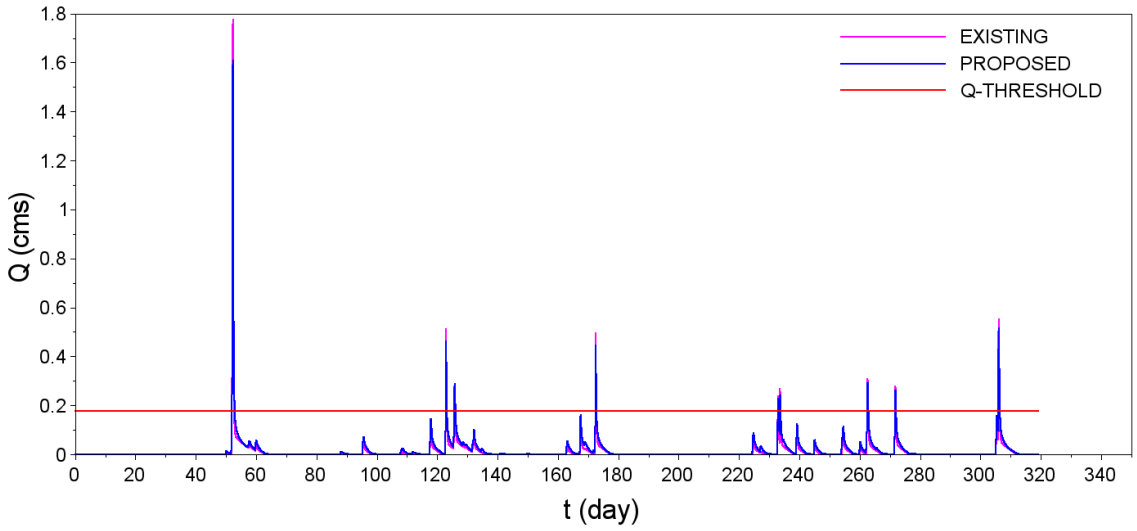

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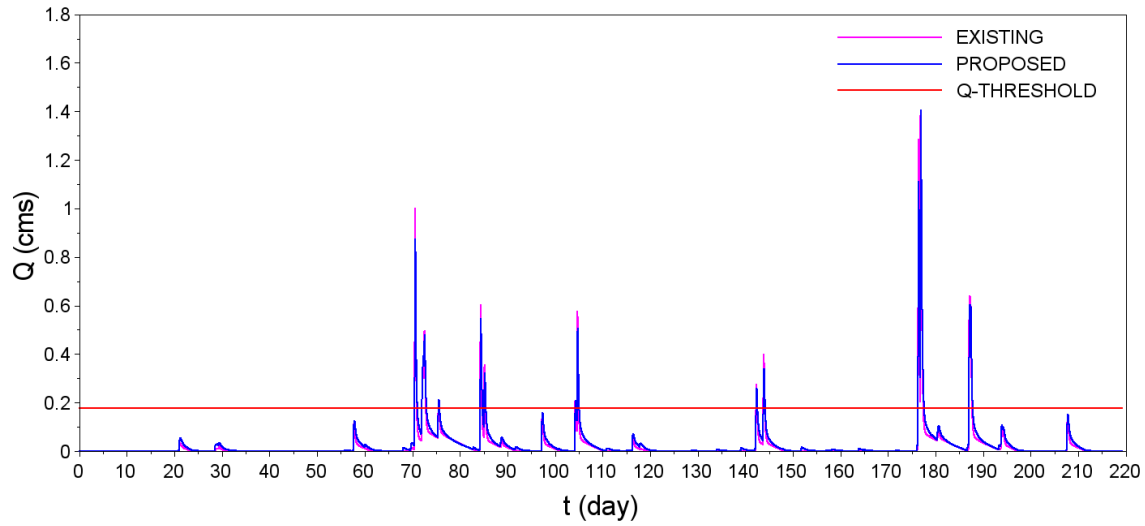

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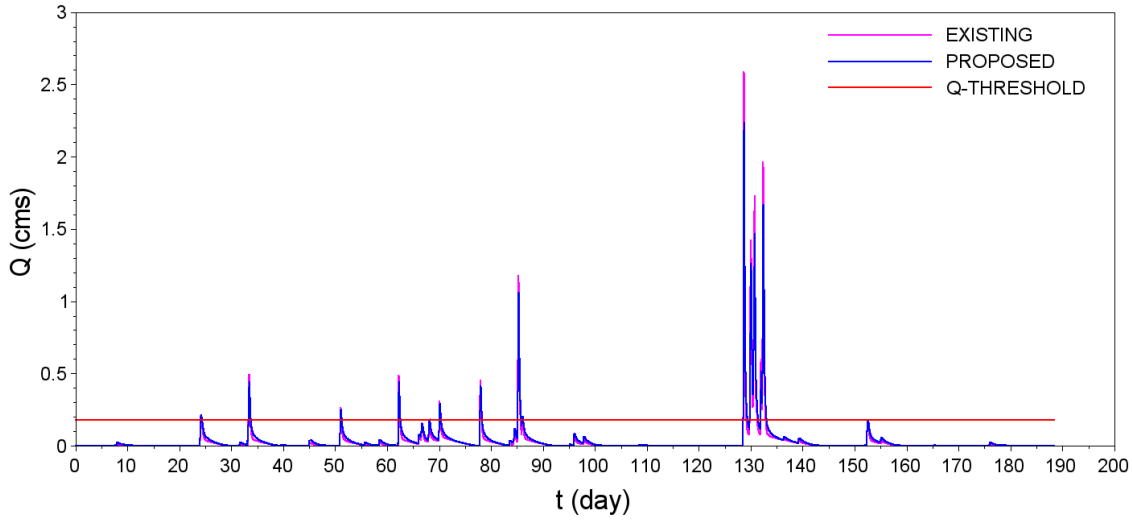

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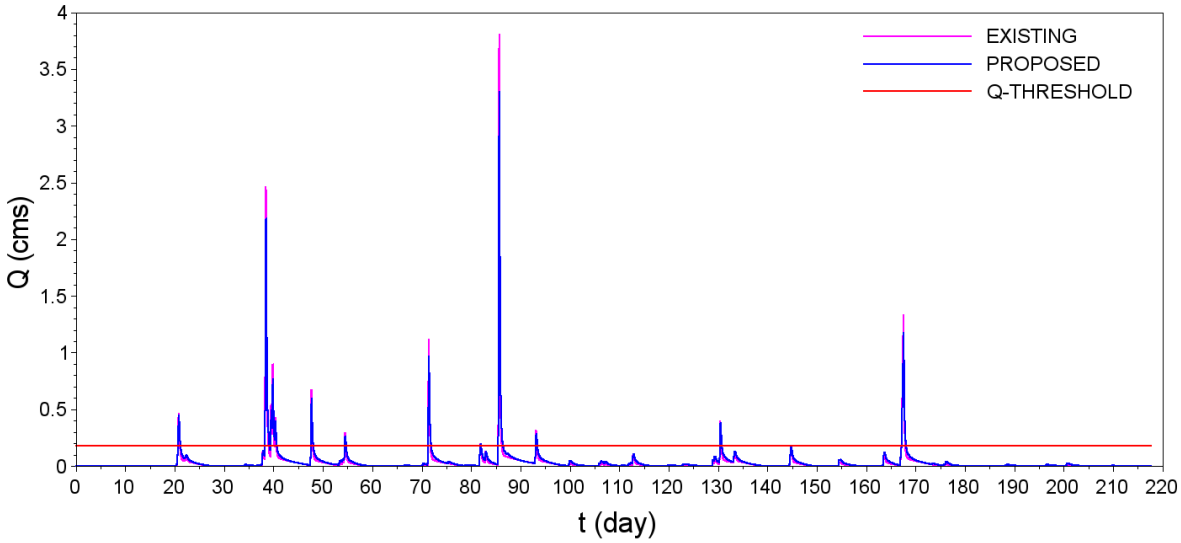

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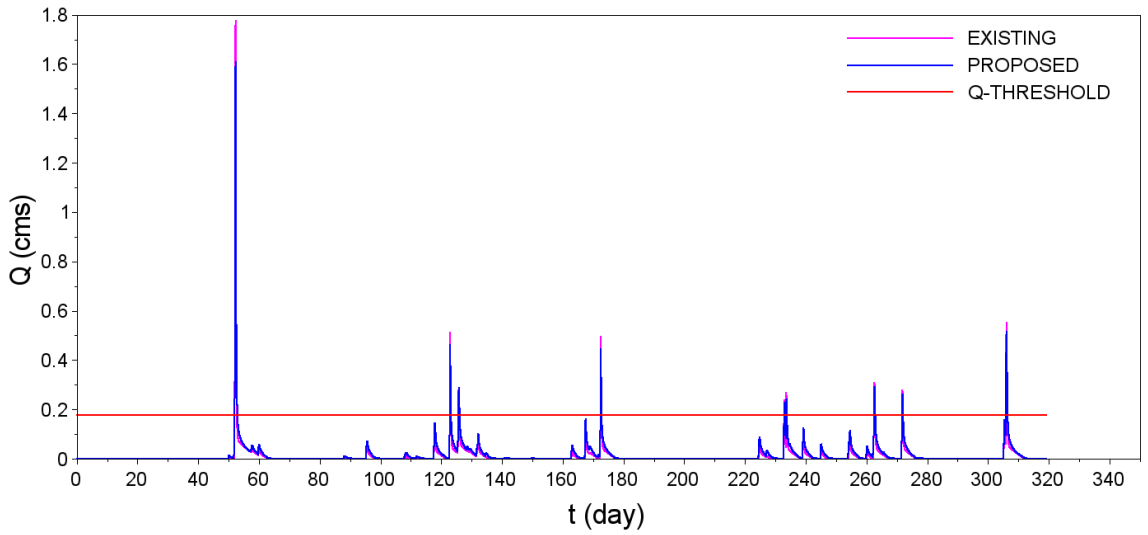

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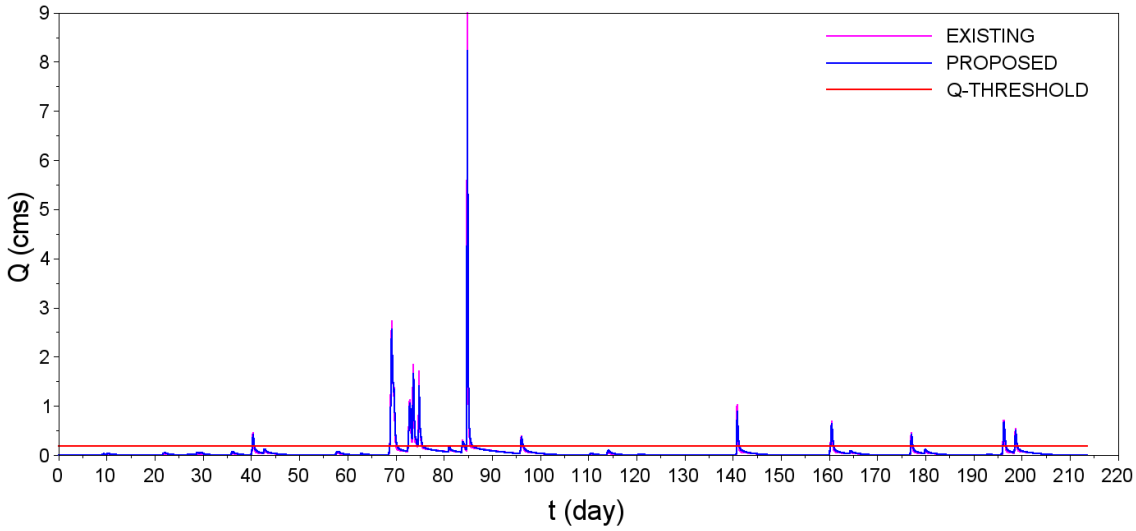

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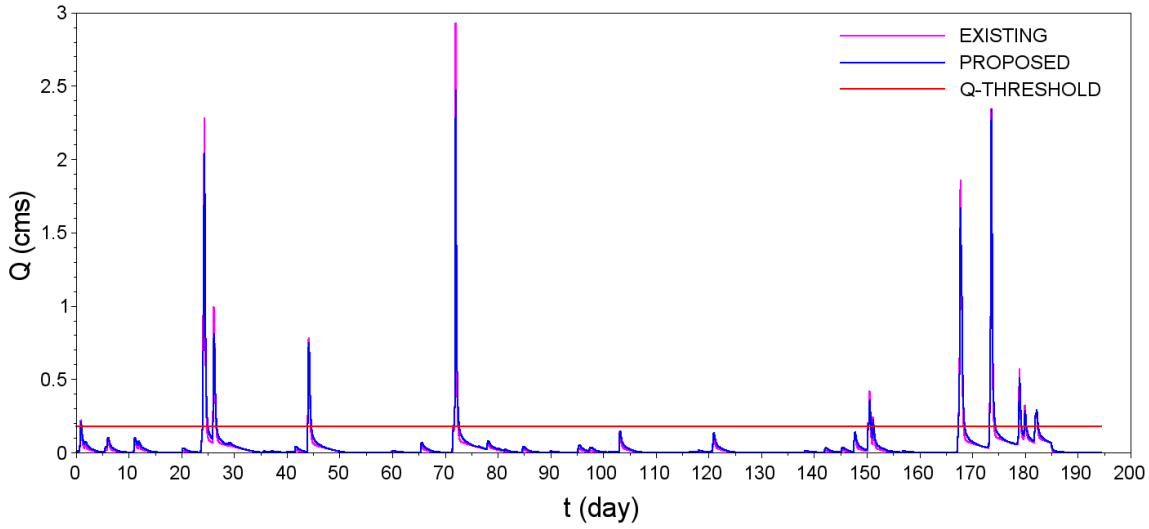

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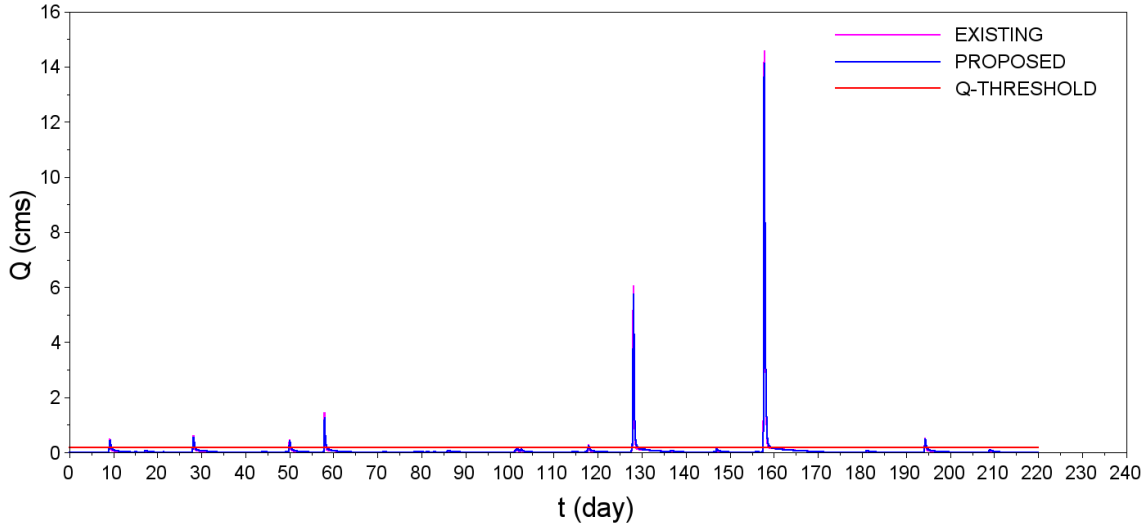

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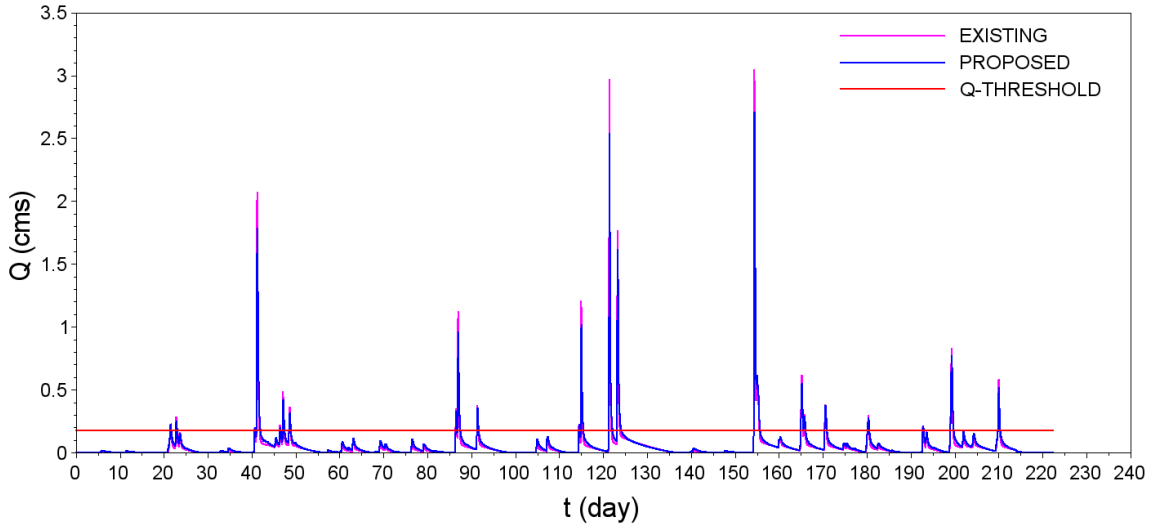

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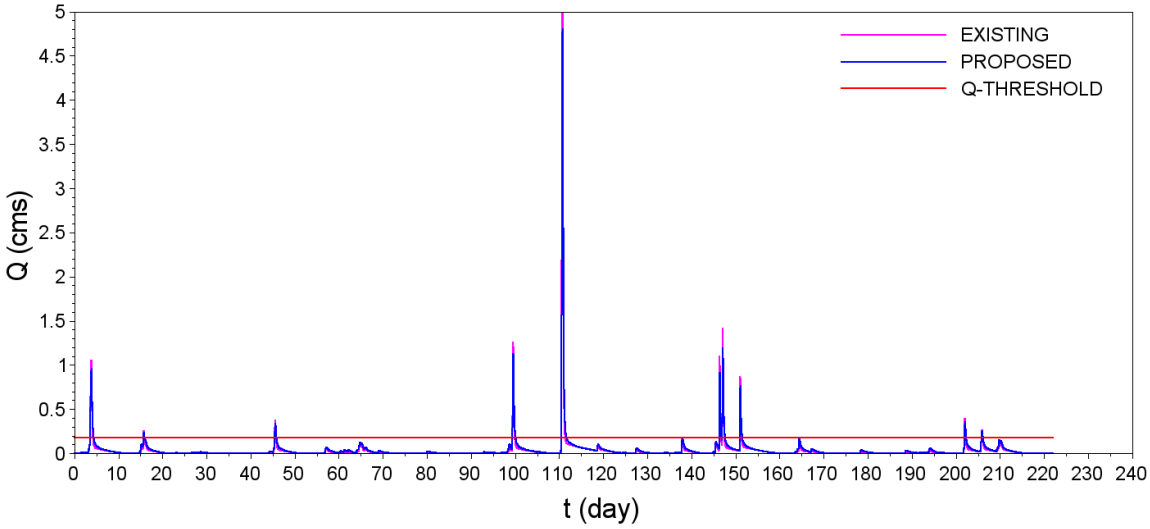

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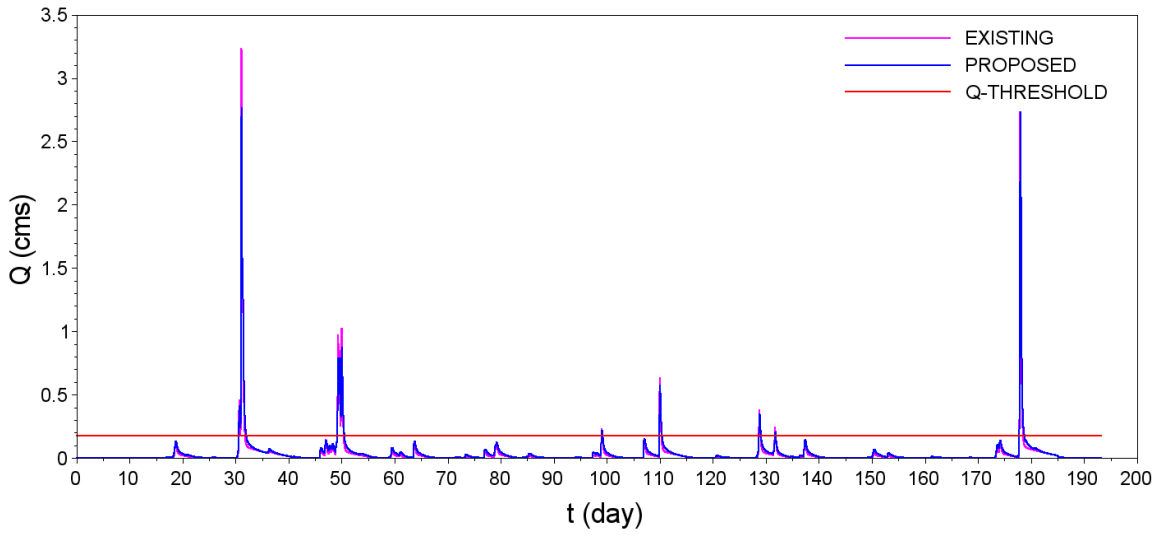

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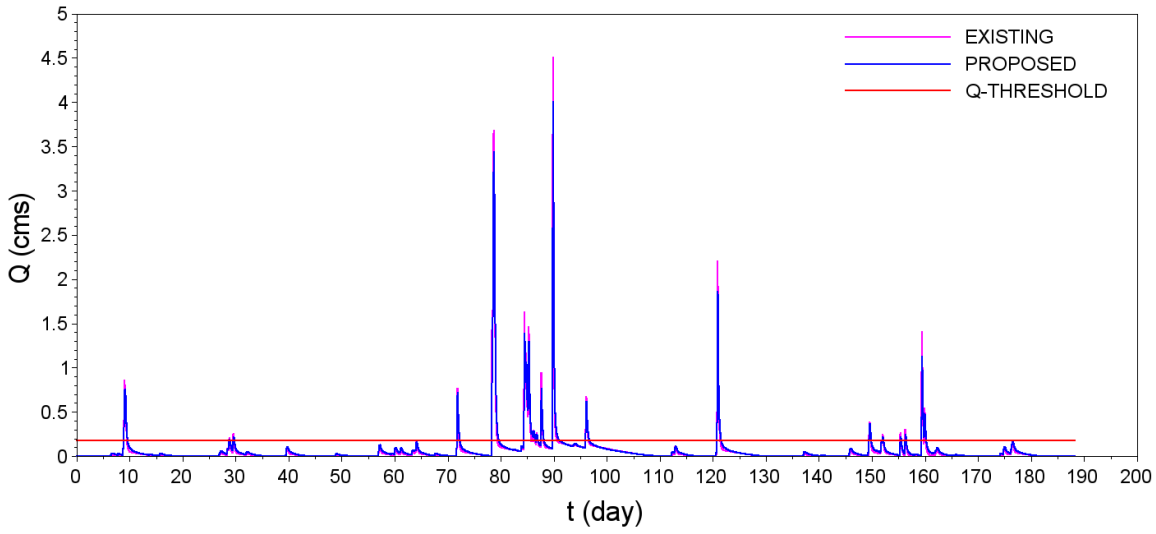

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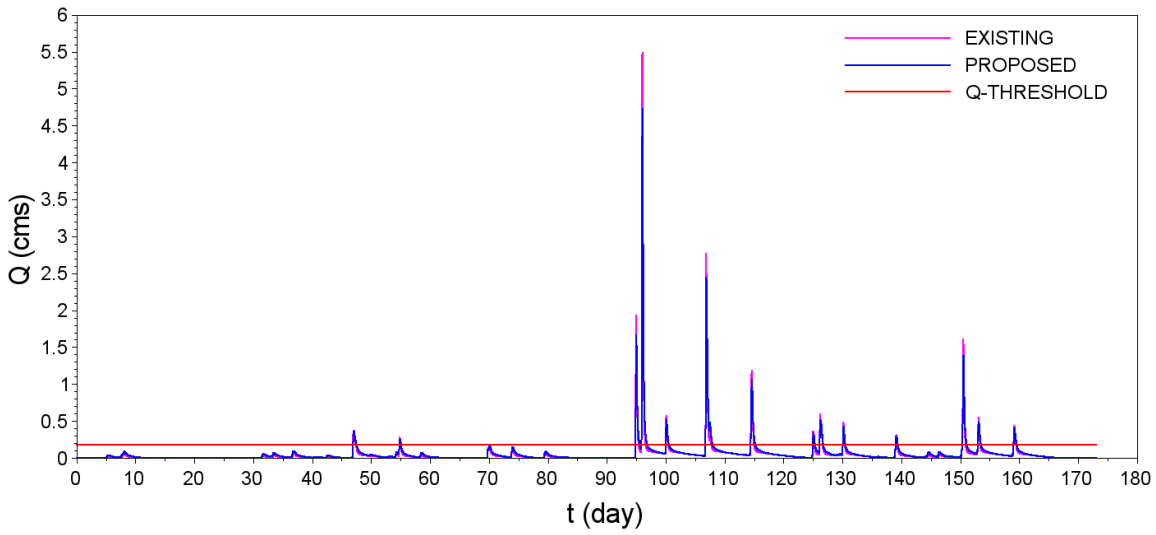

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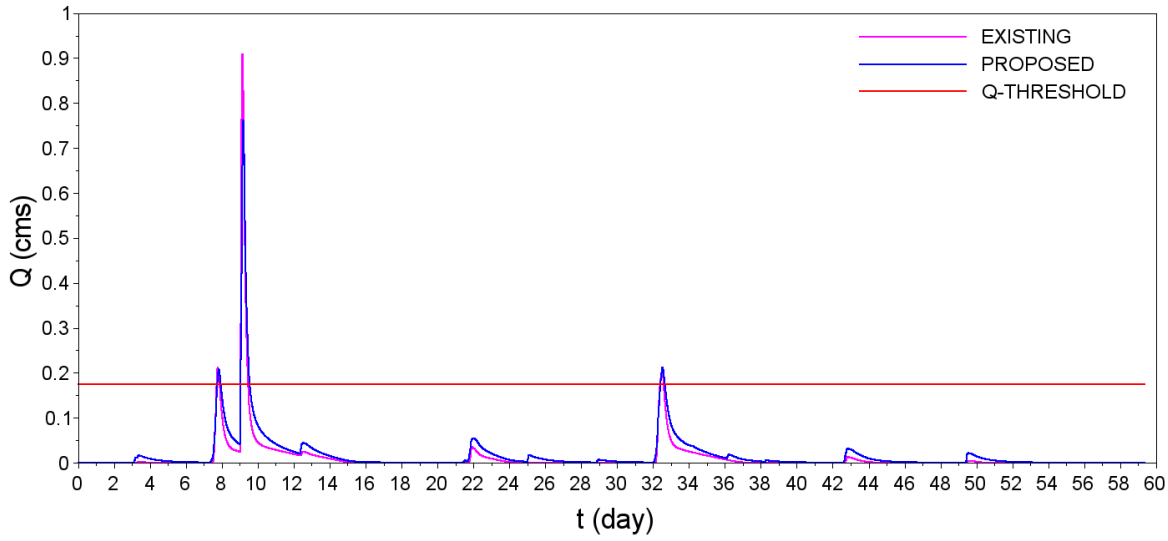

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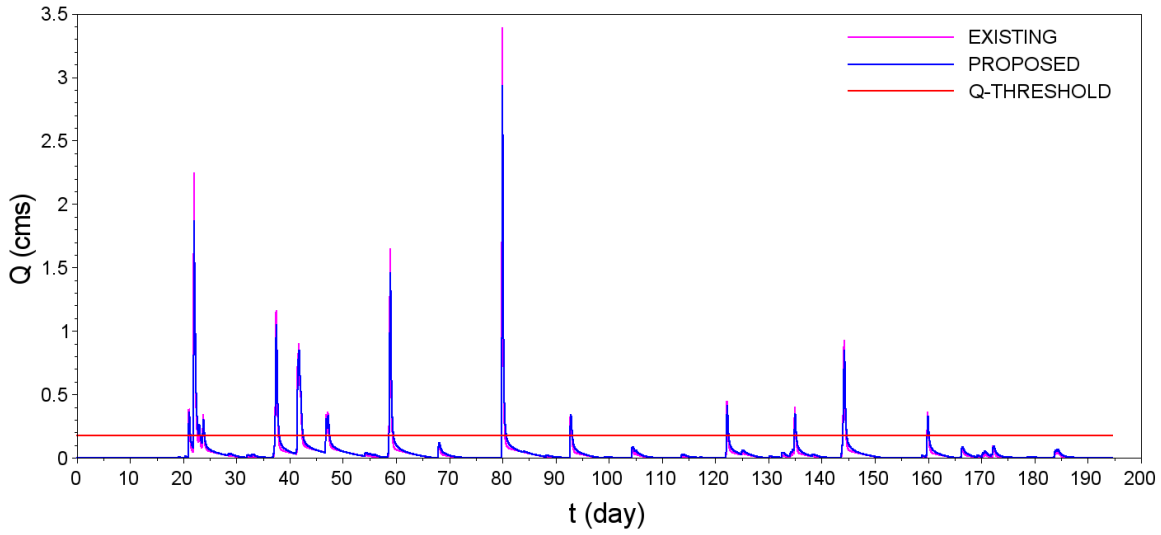

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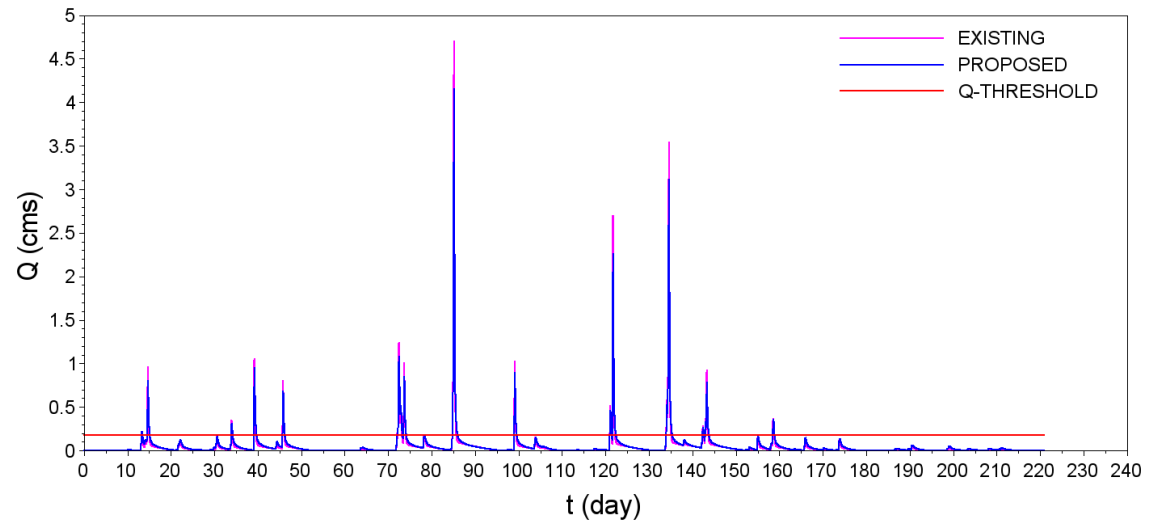

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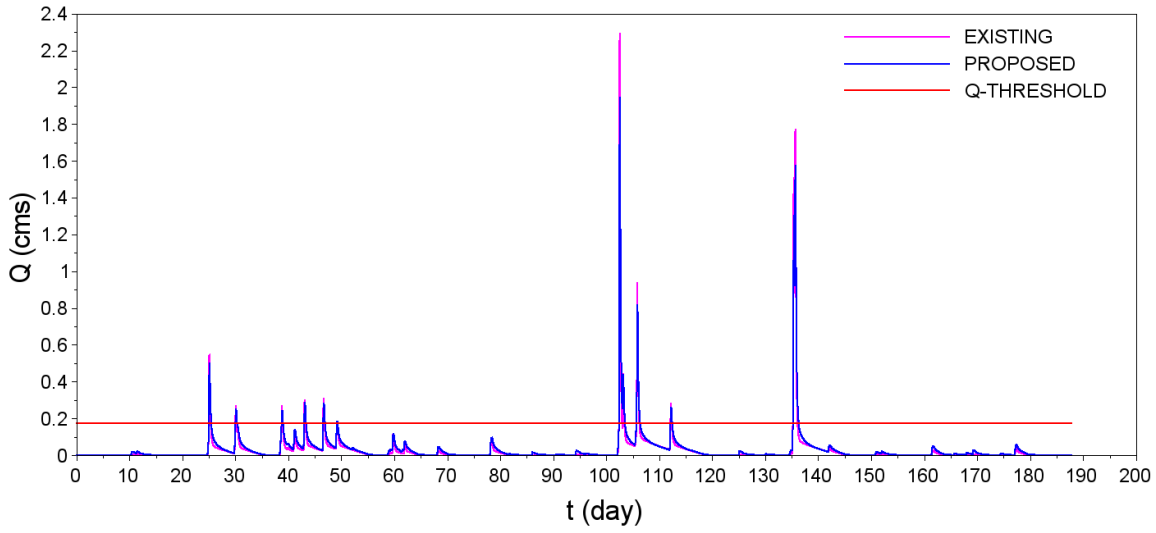
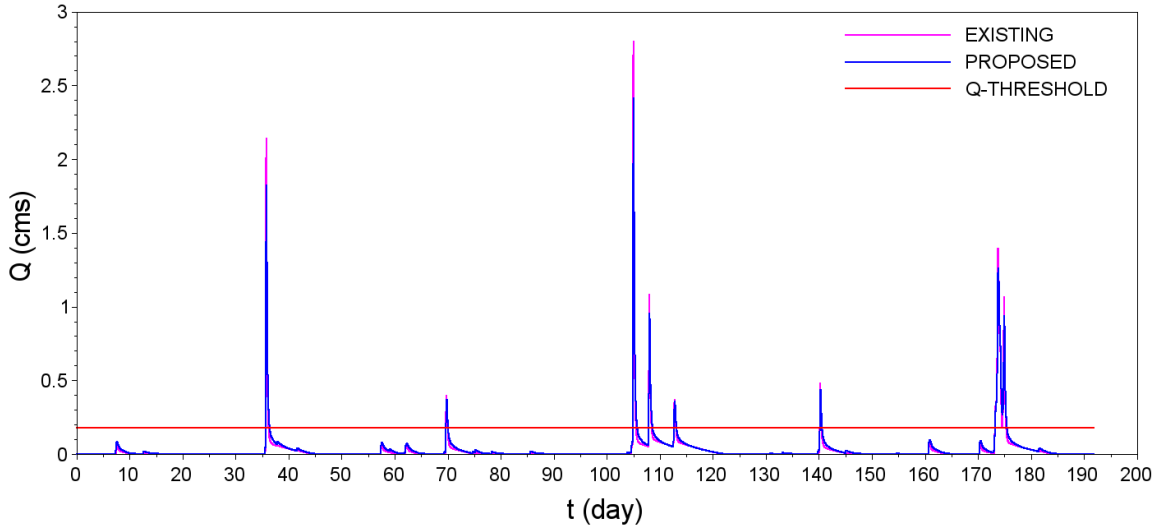


Reach MC3
2015



Reach MC3
2016